# CHEMICAL & METALLURGICAL ENGINEERING

## THIS MONTH

• Who wants to read about blast furnaces in mid-June? Probably you will want to blast your editors for lack of consideration. Blast furnace production of phosphoric acid down at Nashville, Tenn.—a hot subject and a hot spot, but the Victor Chemical plant down there is an outstanding chemical engineering achievement and merits the leading place in this issue. And then, out of the frying pan into the Frigidaire, so to speak, for your trip through this issue ends at Chicago's Century of Progress and the cool breezes of Lake Michigan. One of the A.S.M.E's. papers on the cotton-seed meal industry is published and there are the technical reports of the A.I.Ch.E. meeting. Enroute from Nashville to Chicago are a number of articles worth stopping the train for.

## NEXT MONTH

• July will find us still enjoying Chicago's hospitality and Pabst's famous Blue Ribbon. Much has made print on the Century of Progress—from the story of the down-and-outer who made 80 thousand dollars on the chair concession to the one about the lad who got a job in the hothouse ringing a bell every time a Century plant bloomed. *Chem. & Met.* will have its own feature section on America's "Fair" with reports of Engineering Week and the Chicago Power Show. Feature articles will be of wide interest—Cast Iron in the Chemical Industries—High Pressure Synthesis—Potash Recovery in Portland Cement Industry.

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IS THE old sock overladen with rubber coupons, the kind that snap back? Is your bank down for the count? Then take heed! . . . . . *Chem. & Met.* has money to give away—in return for some of your operating experiences. Operating kinks and shortcuts, particularly, are what we have in mind—experiences that will be useful to other engineers who are up against similar problems. Compensation starts at $5, equivalent to more than a month's supply of cigarettes, or two years of *Chem. & Met.* Contributions start at 100 words, and may well include a rough sketch or a photograph. A hint about the editorial attitude on acceptance—we like 'em short!

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Published monthly, $3 per year. Canada (including Canadian duty), $3.50. Central and South American countries, $3.00. Foreign subscriptions, $5.00 U. S. Currency, or 25 shillings. Single copies 35 cents each. Entered as second-class matter July 13, 1918, at the Post Office, New York, N. Y., under the Act of March 3, 1879. Printed in U. S. A. Copyright 1933, by McGraw-Hill Publishing Company, Inc. Member A.B.C. and A.B.P.

McGRAW-HILL PUBLISHING COMPANY, INC.
330 W. 42d St., New York, N. Y. Cable Address McGrawHill, N. Y.

Branch Offices: 520 North Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, Aldwych, London, W. C. 2; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Greenville, S. C. James H. McGraw, Chairman of the Board; Malcolm Muir, President; James H. McGraw, Jr., Vice-President and Treas.; Mason Britton, Vice-Pres.; Edgar Kobak, Vice-Pres.; H. C. Parmelee, Vice-Pres.; Harold W. McGraw, Vice-Pres.; B. R. Putnam, Secy.

## CONTENTS FOR JUNE, 1933

VOLUME FORTY
NUMBER SIX

•

Plans + Action = Results . . . . . 281

Making Phosphoric Acid in the Blast Furnace . . . . . 283
By H. W. Easterwood

Chemical Engineering Achievements In Petroleum Refining . . . . . 288

Problems in Processing of Cottonseed Meats . . . . . 291
By W. R. Woolrich and E. L. Carpenter

Vinyl Plastics From Carbide . . . . . 293
By G. O. Morrison and T. P. G. Shaw

Montreal and Shawinigan Falls Entertain Electrochemists . . . . . 298
Editorial Staff Report

Design of Grid-Packed Cooling Towers . . . . . 301
By C. C. Furnas and R. H. Newton

Rhodes Marsh Yields Its Sodium Sulphate . . . . . 304
By P. C. Rich

Simplify Your Drying and Grinding Operations . . . . . 306
By Lincoln T. Work

American Gas Association Meeting 310
Editorial Staff Report

With the Chemical Engineers In Chicago . . . . . 313
Editorial Staff Report

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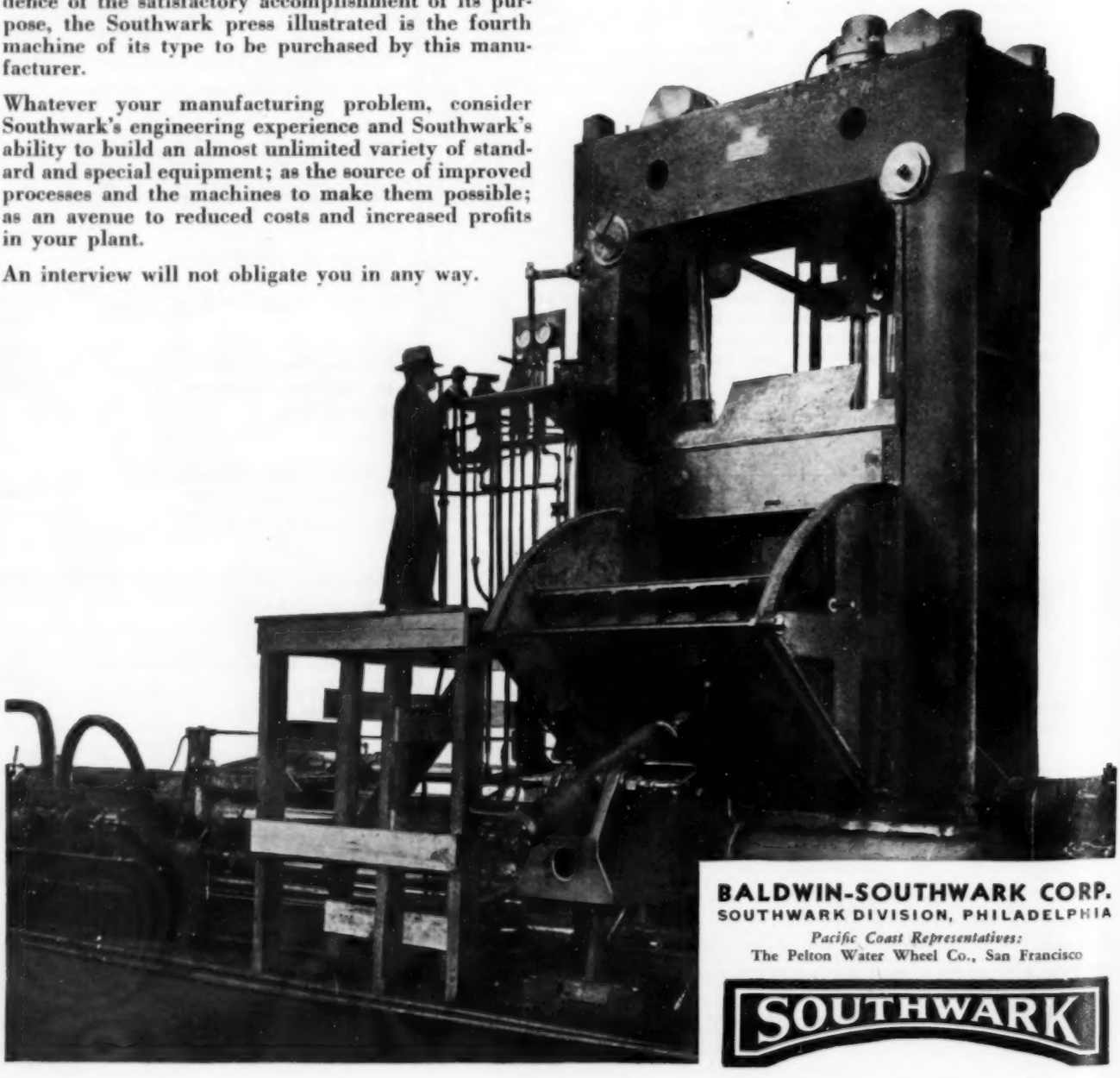

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CHEMICAL
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ENGINEERING

VOLUME 40 ESTABLISHED 1902 NUMBER 6

McGRAW-HILL PUBLISHING COMPANY, INC.

S. D. KIRKPATRICK, Editor

JUNE, 1933

# PLANS + ACTION = *RESULTS*

ACADEMICIANS—editors as well as college professors—often regard a thing accomplished once the problem is analyzed and its solution put down in the form of a plan. It is not surprising, therefore, that much of the recent progress we have been making in Washington is still in the plan stage, even though some of these plans have become the law of the land while others continue in the throes of controversy and debate. Perhaps all of us have wasted too much time in the details of planning, forgetting that success depends on the way the plans are administered and thus translated into actual achievement.

The President's program of industrial recovery is a case in point. Its opponents—and at one time or another they have included some of the recognized leaders of chemical industry—regard the plan as an attempt to write into a single statute all of the social remedies necessary to cure our industrial ills. They tell us it means the surrender of the traditional principles of industrialism. They say that its licensing feature holds the threat of commercial exile, that its labor provision will kill the open shop, that without tariff protection our higher prices will make us the shining target of unfair competition from abroad. They fear that industry will be ground between the millstones of increasing wages and fixed prices. Forgetting the groundwork of experiment and research on which industry itself is founded, they distrust the same approach to the all inclusive problem of industrial coordination.

These critics, it seems to us, lose sight of the fact that the motivating spirit behind the national recovery plan is to give employment, to raise wages and thereby to rebuild the purchasing power of America. Industry has become confused by its own constantly recurring references to production quotas, price fixing and other bugaboos it has read into the wording of the measure. Obviously many of the traditional viewpoints of industry must go, just as we are throwing aside the passive resistance that has already proved ineffective in stemming the tide of the depression. But the sooner we accept the experimental spirit in which the legislation was conceived, the quicker will be our real progress.

What does all of this mean for chemical engineers and for executives in chemical industry? Fortunately, we have not suffered to the same extent as other industries from the particular ills which this legislation, as a by-product of its principal function, was designed to remedy. With the exception, perhaps, of insecticides and fertilizers, our trade practices have not been open to serious criticism. The alkali and alcohol producers early taught us the bitter lesson of price wars. Over-capacity is not a major problem, especially when we eliminate obsolete plants and equipment. Therefore, it would seem that the greatest gains are to be made in the indirect benefit that will come from industrial recovery on a national scale.

Chemical executives, if they do not already know it, will have to learn again the value of cooperative effort.

# EDITORIALS

## Business Is Better

PRODUCTIVE activity increased more rapidly in April and May than in any comparable period in the history of the United States. The Federal Reserve index, which stood at 60 in March, rose to 67 in April and has been given a preliminary figure of 76 for May. But what about prices? In answer to this question a well-known economist told the executives of chemical industry on June 1, that we are entering a long swing of mounting commodity prices and barring drastic monetary adjustments, the next fifteen months will see a continued and rapid rise. *Chem. & Met.'s* price indexes given elsewhere in this issue would seem to confirm the economist's prediction.

## One Promising Prospect For the Tennessee Valley

PESSIMISTS forecast nothing but failure for the efforts of the newly established Tennessee Valley Authority. Pessimism will not, however, deter the able group of three leaders named to organize the development of this great mid-continental experiment. And chemical engineering offers at least one attractive prospect for their study.

The United States is short of pulpwood. Depletion of our great coniferous territory of the Northeastern states has reduced production far below consumption. Here is an increasing opportunity for the Tennessee Valley Authority.

One specific procedure can be suggested. On May 1 representatives of the pulp and paper industries of this country and Canada visited the Georgia experimental plant in Savannah, where they saw the successful production on a semi-commercial scale of ground wood, sulphite pulp and newsprint from the slash and other species of young Southern pines. These studies of Dr. Charles H. Herty, if transferred from Georgia scrub pine to Tennessee Valley weed wood, might afford extremely important results in a comparatively short time. Based on such scientific knowledge, a new type of forestation would be practiced. In fact it might not be reforestation at all. It might require the encouragement of the weed type of present timber growth and certainly new sivicultural methods would be expected. The practical results looked for would be quick-growing timber supplies with short reforestation cycle and pulpwood manufacturing on an economic basis in territory now marginal or sub-marginal from the standpoint of agriculture.

## Illinois Must Tax To Build Sewage Works

SUPREME COURT decisions must be observed. This, in substance, is the meaning of the ruling on May 22 directing Illinois to proceed with proper sewage disposal works in Chicago and environs, even though the State Legislature may not find it politically expedient to raise taxes for that purpose.

"The question, then, comes down to the procuring of the money necessary to effect the prompt completion of the sewage treatment works and the complementary facilities. To provide the needed money is the special responsibility of the State of Illinois. . . . That responsibility the State should meet. Despite existing economic difficulties, the State has adequate resources, and we find it impossible to conclude that the State cannot devise appropriate and adequate financial measures. . . . the State of Illinois is hereby required to take all necessary steps . . ."

It is clear that the Court meant including imposing of new taxes if necessary. It is a striking case, in which a Federal authority compels state taxation. And it is a case in which chemical engineers will be particularly interested because much new technology is certain to develop in the needed Chicago sewage-disposal enterprise.

## Is Deferred Maintenance Responsible for This?

IN ITS ANNUAL report on accidental injury rates in the chemical industry the National Safety Council calls attention to a thought-provoking condition that has become increasingly evident during the latter years of the depression. This is the growing divergence between the trends of accident frequency and severity. While the frequency rate has fallen considerably and continuously since 1926, the severity rate dropped to a low point in 1929, but has again risen sharply until, in 1932, it had almost reached the 1926 level. Accidents are most frequent, it appears, in fertilizer plants, and most severe in explosives manufacture. High severity rates are also found in plants making dyes, industrial gases, chlorine and alkalis, pharmaceuticals and fine chemicals, and vegetable oils.

Causes for the accidents are not given, but it is an open question whether at least a contributing cause for the increasing severity may not be the slackening in maintenance and the growth of unsafe conditions. It is a fact that much maintenance has been deferred and that this course does introduce hazards. With returning business optimism there is no longer an excuse for further delay in this imperative function.

## Chemical Engineering's Quarter of a Century

ON JUNE 22, 1908 forty men met in the Engineers' Club in Philadelphia and founded the American Institute of Chemical Engineers. Last week ten times that many met in Chicago for the twenty-fifth semi-annual meeting of the organization. It is only a coincidence that the latter meeting should occur at a time when the world is helping Chicago celebrate its first "Century of Progress." But it is more than a coincidence that chemical engineering in its first quarter of a century should not only have contributed so much to the advance of industry but is today on the threshhold of a much greater development.

# MAKING PHOSPHORIC ACID in the BLAST FURNACE

By HENRY W. EASTERWOOD

*Victor Chemical Works*
*Chicago, Ill.*

PHOSPHORIC ACID is one of the world's most important acids. Victor Chemical Works has for the past 30 years been interested in producing pure phosphate compounds largely for food purposes. Thus it can be readily seen that every possible effort has been made to increase the purity of our products. This aim is responsible for our undertaking the development of the blast furnace process for making phosphoric acid.

Use of the blast furnace for phosphoric acid was first advocated by Brisons (B.P. 3,515) in 1868. This method apparently did not prove commercially attractive at that time, and we find that during the next 30 to 40 years the development was largely confined to electric furnace processes.

From 1917 to 1923, however, there were the investigations of the Bureau of Soils in the U. S. Department of Agriculture on the volatilization of phosphorus and the production of phosphoric acid for concentrated phosphate fertilizers. Details of this work are shown in Department Bulletin No. 1179, published in 1923. Several types of oil-fired furnaces were built and operated experimentally for short periods with promising results.

**Blast furnace now in use at Nashville**

These experiments were based on the principle that $SiO_2$ at high temperatures acts as a strong acid, and is capable of replacing the $P_2O_5$ in the normal tricalcium phosphate which is the major constituent of the natural phosphate rock used. Carbon was introduced to reduce the $P_2O_5$ to elemental phosphorus as soon as it was liberated, so that the reaction between CaO and $SiO_2$ could proceed to completion with the liberation of substantially all of the $P_2O_5$. The reaction considered was:

$$Ca_3P_2O_8 + 3SiO_2 + 5C = 3CaSiO_3 + P_2 + 5CO$$

On a weight basis this corresponds to a silica-to-lime ratio of approximately 1.07. In the Government experiments an excess of silica was used and the silica-to-lime ratios ranged from about 1.40 up to approximately 1.70. Laboratory experiments fully confirmed the fact that the higher silica ratios gave higher volatilization of the phosphorus in a shorter period of time than the lower silica ratios. I have purposely mentioned these ratios, based on perfectly sound reasoning, as they have since cost the Victor Chemical Works, who at this time (1924) undertook the commercial development of the blast furnace method, large sums of money in their efforts to operate with highly silicious slags.

In our investigation a small blast furnace with an overall height of approximately 25 ft. was built at the Chicago Heights plant in the early part of 1924. The auxiliary equipment consisted of a conventional type dust catcher, and gas mains leading to three hot-blast stoves of the usual two pass or "Cowper" type. The stove off-gas main led through a bank of cooling and hydrating tubes to a 60-pipe Cottrell electrical precipitator. The air blast was furnished by a motor-driven Connersville blower. A sizable stock of charge material was made up by briquetting finely ground mixtures of phosphate rock, silica sand and coke breeze, correspond-

An abridgment of the paper presented by the author, under the title of "Manufacture of Phosphoric Acid by the Blast Furnace Method," before the Chicago meeting of the American Institute of Chemical Engineers, June 14-16, 1933.

ing approximately to the briquets used in the government experiments except that due allowance was made for the silica content of the fuel coke.

The stage was now set for our first campaign. The furnace was blown in on May 10, 1924, and blown out again on May 15—our first failure. Several thousand pounds of $P_2O_5$ had been charged and only a few hundred pounds recovered as acid. Sufficient unburned gas and elemental phosphorus had passed through the system to set fire to the precipitator structure, causing the shut-down. The acid produced hardly deserved the name, since the impurities present rendered it unfit for any commercial purpose.

After repairing the electrical precipitator and cleaning out the whole system our second campaign was started on May 26, 1924, and ended on June 2. The furnace was then shut down because we could not burn the gases produced. There wasn't enough combustion space in the three stoves. Nor was the operation of the furnace satisfactory. The dust catcher, mains, stoves, coolers, and even the precipitators were partially stopped up with solid residues or accumulations. The silica-to-lime ratio during this run was 1.11 and the $P_2O_5$ content of the slags varied from 1 to 12 per cent.

The third campaign was started on August 20, after a fourth stove and two horizontal fire-tube boilers had been installed to increase the gas burning capacity. A second blower and additional coolers were also installed and the precipitator was changed from a suction to a pressure type by placing the draft fans between the coolers and the precipitator. The fan-connecting mains were of wooden construction, and leaked gas so badly that after about seven days the furnace was shut down and repairs made.

The fourth blast was started about a week after the above shut-down, and also lasted for seven days. These were seven days of constant difficulty in getting the slag out of the furnace hearth. After shutting down, it was found that the cooling water on the bosh had leaked into the furnace. Further, we had completely ruined the two boilers in these two seven-day runs. The expected protective coating of dust had not developed in the boiler tubes as it did in all other pieces of equipment.

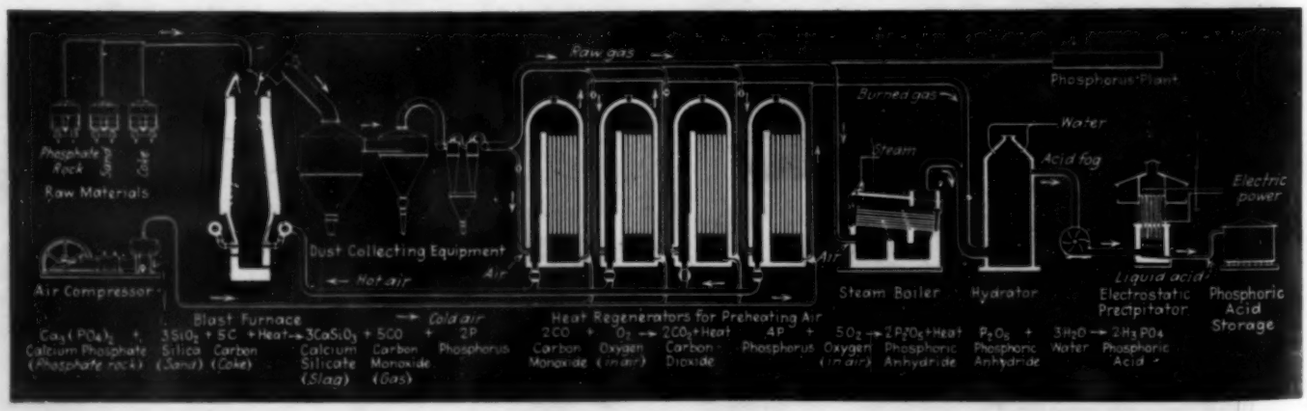
Up to this time all of our experimental campaigns had been complete failures, and we had made little progress toward our objective. Our fifth campaign was started on Nov. 3, and lasted a full 30 days. Cleaning of gas and draft mains and poor combustion of the gases were continual sources of trouble. During the first week a sufficiently high proportion of coke was charged to keep the furnace very hot and no difficulty was had in flushing out the slag. Because of the large amount of fume-like dust produced, we increased the briquet burden, which cooled the hearth down to a point where it was just possible to remove the slag. This slag ran about 6 to 8 per cent $P_2O_5$ and represented about 30 per cent of the $P_2O_5$ charged. The fume production was noticeably decreased, but was still sufficiently high to give us considerable trouble in keeping the mains open. A typical dust of the type which collected in the furnace downcomer and gas mains analyzed CaO, 3.5 per cent; $SiO_2$, 17.0; $P_2O_5$, 60.0; $Fe_2O_3$, 2.0; $Al_2O_3$, 4.0; and carbon, etc., 13.5 per cent.

This material or the major portion of it was probably volatilized in the furnace hearth and passed up through the charge and into the downcomer, dust catcher, and gas mains where it condensed to a sintered, sponge-like mass which was very difficult to clean out. As a temporary expedient, air was introduced into the mains so that partial combustion of the gases kept the fume residue moving until it reached a cleanout point. Needless to say, large portions of this fume carried into the stoves, plugging up the checkers, and into the precipitators, adding impurities to the acid collected. At the end of the 30 days, practically all of the stove checkers were stopped up. It was necessary to use an air drill to remove these deposits. The average silica-lime ratio of the charge during this run was 1.14 while a ratio of 1.03 was obtained in the slag, indicating a selective volatilization of the silica.

After installing numerous cleanout doors and a hot-plate dryer for drying the briquets, and insulating the furnace hearth, we started Blast No. 6 on Feb. 2, 1925. This run lasted 12 days, and while showing more promising results than any of the previous runs, demonstrated the futility of operating without some means of controlling the fume problem.

Prior to our seventh run, May 4 to 14, we added 10 ft. additional height to the furnace, increased the size of the downcomer, and put in a larger dustcatcher. Substantial improvement was noted, and we were able to keep the downcomer, dustcatcher, and mains open. Combustion at the stoves was much better, although not complete. We were able to maintain a blast temperature

**Flow chart of Victor Chemical Works' phosphoric acid process**



of 675 deg. C. and obtained a volatilization of 83 per cent of the $P_2O_5$ charged with a total recovery of 45 per cent. The acid showed 1.6 per cent of iron and aluminum phosphate as its major impurities. It was decided to shut down, and make extensive changes in the equipment. The silica-lime ratio of the briquets had been 1.07, and that of the slag, 0.96, during this blast, still showing the selective volatilization of silica.

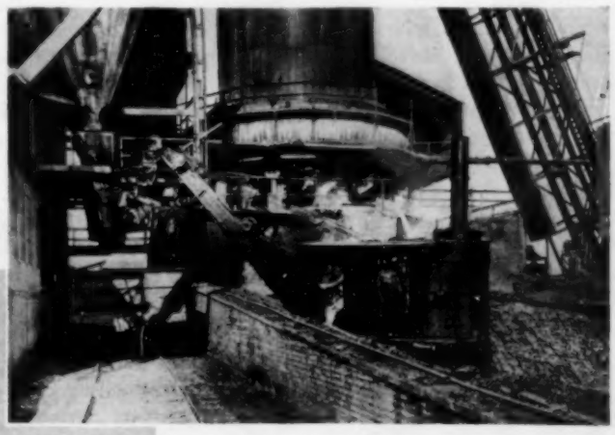
In order to insure complete combustion of the gases, a central combustion chamber was provided in which the gas and phosphorus vapor could burn continuously and efficiently at a constantly high temperature. The hot products of combustion were then led through suitable valves to the hot-blast stoves. In addition to this provision, we put in a large spray tower as a substitute for the bank of cast-iron cooling and hydrating tubes. An additional Cottrell precipitator was installed for more efficient collection of the acid. A new briquet plant was built with a continuous dryer.

With these improvements installed, we entered on our eighth campaign which lasted from Dec. 10 to 19, 1925, when a blown-out tuyère flooded the hearth with water and caused the mass of slag and semi-fused charge in the bosh to freeze up. It was necessary to stop and dig out the charge. The nine days of uninterrupted operation showed us an average volatilization of 84.7 per cent, and a total yield of 52.5 per cent. The briquets had an average silica-lime ratio of 1.13 and contained 75 per cent carbon in excess of that theoretically required for reduction of the $P_2O_5$. The silica-lime ratio of the slag was 0.92.

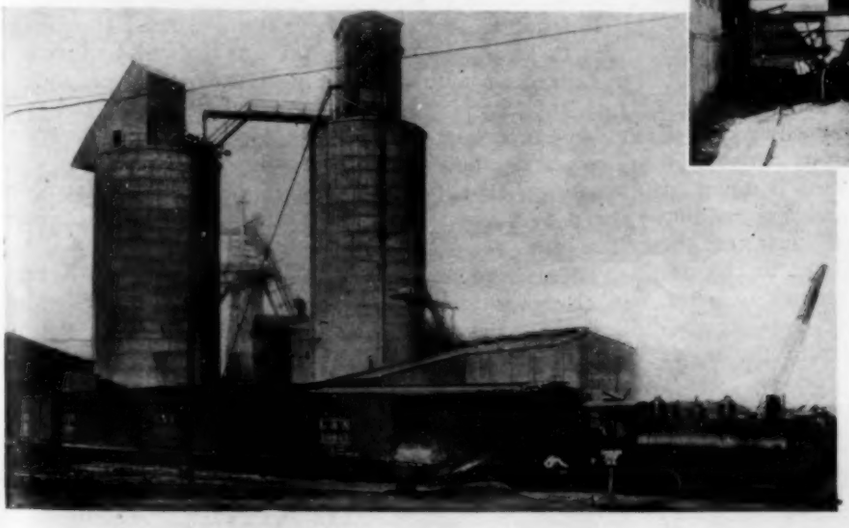
In an effort to control the selective volatilization of silica, the briquets for our ninth campaign, which started Jan. 16, 1926, and lasted 25 days, were made up with a silica-lime ratio of 0.95. We also used pulverized Pocahontas coal as the reducing agent, instead of coke breeze as was used in the former campaigns. Excess carbon in the briquets was varied from 50 per cent up to 150 per cent of that theoretically required. The average volatilization obtained was 85 per cent, and the yield was about 67 per cent of the $P_2O_5$ charged. The silica-lime ratio of the slag was 0.89, showing a marked improvement in the excess silica volatilization, although it did not eliminate the fume problem. The furnace was shut down to clean the stove checkers.

The stoves were cleaned and the tenth blast started on Feb. 18, and lasted through March 30, a total of 40 days. A total of 491,000 lb. of $P_2O_5$ was charged. The average volatilization was 79 per cent and the yield was 75 per cent. Thus we learned that better yields of a purer acid could be obtained by using silica-lime ratios below 0.90; and that a higher phosphate burden with its resultant lower hearth temperature materially reduced the fume volatilization. A blast temperature of 610 deg. C. was used, and the excess carbon was maintained around 50 per cent. In spite of the reduction in fume production, we collected sufficient amounts in the stove checkers to cause us to shut down after 40 days.

We installed an additional dust collector in series with the previous collector and started Blast No. 11 on July 15. This blast lasted three weeks, and was purely experimental in nature. Except for a few days at the end of the previous run, this was the first time we had used run-of-mine phosphate rock. This rock analyzed 24.2 per cent $P_2O_5$. Sulphite liquor was used as the briquet binder. The amount of carbon included in the briquets was varied between 50 per cent above theoretical, and no carbon. Somewhat irregular results were obtained, but in general it was shown that better volatilization and yields were obtained with the higher carbon contents. For six days with the carbon content averaging about 40 per cent above theoretical, we showed an 81 per cent volatilization with a 76 per cent yield. The silica-lime ratio of the slag was 0.84, the blast temperature 700 deg. C. and the iron and aluminum phosphate in the acid amounted to 2.18 per cent. The second dust collector removed sufficient of the fume dust to enable us to



**Slag handling at the base of the blast furnace**



**Storage silos for ground and unground phosphate rock**

operate the full three weeks without loss of stove heat and without having to clean the precipitators.

During each of these campaigns we obtained just sufficient encouragement from one angle or another to cause us to try again, so on Sept. 7, 1926, we launched the twelfth campaign which lasted 45 days. A low silica-lime ratio was used in an effort to control further the volatilized fumes. The average ratio in the slag was 0.78. The volatilization averaged 82.7 per cent and the yield 67.0 per cent with an average daily production of 12,450 lb. of $P_2O_5$, which was the highest production obtained so far. A blast temperature of 665 deg. C. was maintained throughout the run. The fume collection in the stove checkers was not sufficient to interfere with the heat absorption. Further evidence of the reduction in fume volatilization was shown in the acid, which contained only 1.4 per cent iron and aluminum phosphates. But production costs were still too high, and purity of product too low, so operations ceased.

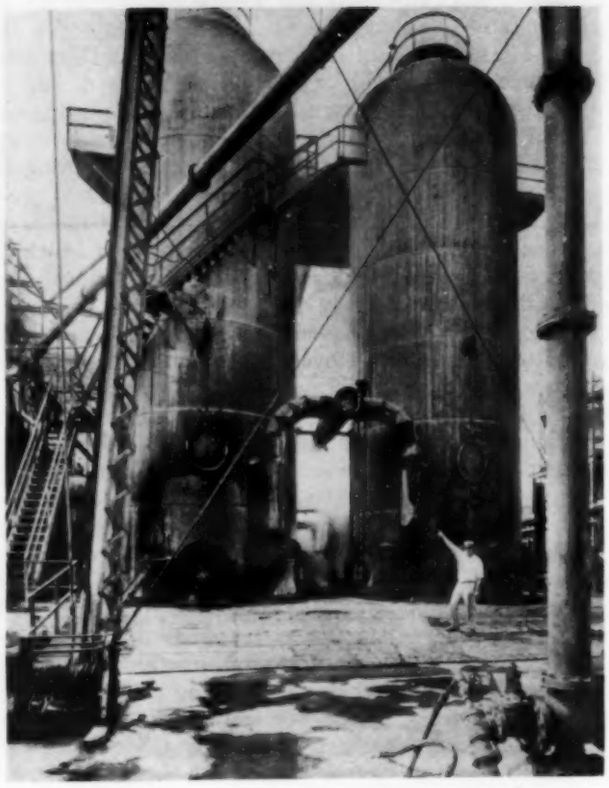
A careful and thorough analysis was now made of all the results obtained and the question of the commercial possibilities of the process was most carefully studied. Although close to three-quarters of a million dollars had been spent on this research, it would have been inadvisable to continue the work, unless there was a reasonable chance of the development of a process at least equal to any other known process. After considering all the facts in the matter, Mr. Kochs, the president of our company, authorized a continuance of the work, so on Oct. 10, 1927, the thirteenth and lucky campaign was started.

The plant was thoroughly overhauled, a new lining was put in the furnace, the stoves were repaired, two additional dust collectors were installed, the precipitators were retiled, and several improvements were made in the briquet plant.

Run-of-mine rock was used, and was briquetted with 66 per cent excess carbon over that theoretically required. Sufficient additional silica was charged to maintain a silica-lime ratio of 0.85 in the slag. Less hanging of stock in the furnace shaft was noted, and less rodding down was required to break up arches of stock near the top. This improvement was due no doubt to the use of briquets with less than the required amount of silica, the needed silica being charged separately, thus preventing premature softening of the briquets in the upper part of the shaft.

An average volatilization of 78 per cent and a yield of 62 per cent was obtained over the entire 67 days of the blast. The average iron and aluminum phosphate in the acid was 0.85 per cent for the last 30 days. A blast temperature of 680 deg. C. was maintained without any draft or combustion trouble at the stoves. Fume troubles were minimized. The run proved that an improved quality of acid could be obtained, that hot blast stoves could be made to function over long periods with efficiency, that precipitator maintenance cost could be reduced by the use of carbon tile, and that numerous difficulties in mechanical operation could be overcome.

This closes the chapter on the Chicago Heights furnace operations. The thirteenth blast had shown us commercial possibilities for a furnace, if operated in the proper geographical location, and construction at Nashville was decided upon.



**Hot-blast stoves for heating furnace air**

### Nashville Furnace Operation

It required 13 months to design and build the Nashville furnace plant. This plant was laid out to function in connection with our existing phosphate plant, and of such capacity as to supplement the production of acid by an efficient Dorr plant already operating at Nashville. The furnace had an overall height of about 75 ft. The producing capacity was 75,000 lb. of $P_2O_5$ per day compared with a maximum of 13,000 lb. per day at Chicago Heights.

There were numerous problems in design to be met in changing from the Chicago Heights furnace to the larger furnace, as we had only our earlier experience to guide us. Some mistakes were made, but on the whole, we had a fairly well balanced plant, the cost of which was approximately $2,000,000.

Operation was started in February, 1929, and in less than a month we found by sad experience that the conclusions reached at Chicago Heights in regard to excess briquet carbon were in error. The briquets initially used at Nashville contained approximately 50 per cent excess carbon over that theoretically required. After the furnace had been operating about three weeks, and everybody was feeling optimistic, the tuyères suddenly went black, we could not obtain any slag from the hearth, the blast pressure jumped to double the normal amount, and it was necessary to shut off the blast. A large hole was cut in the side of the hearth jacket just above the tuyères, and an oil burner supplied with tank oxygen for combustion was used to melt back and up into the bosh. A charge of dynamite was placed up into this hole, and exploded to break a passage so that we could put the

blast on again. Nearly two carloads of red-hot dust poured out.

No more excess carbon was used in the briquets. We did not quite learn our lesson, as we cut off only the 50 per cent excess of carbon, leaving the theoretical amount of carbon incorporated in the briquets, and after six weeks more of operation, this same experience was repeated. We then cut off half of the remaining briquet carbon leaving 50 per cent less than the theoretical amount in the briquets. No further trouble from dust in the furnace was noted. Strange to relate, the volatilization, yield, and purity of acid were considerably increased by this reduction in briquet carbon. This discovery resulted in U. S. Patent 1,867,241.

This furnace was operated a little over a year when it was decided that we would discontinue operating our wet-process plant and make our full requirement of acid by the furnace method. We then dismantled the old furnace and erected the present one. By thorough preparation and planning, this job was completed in the remarkably short time of six weeks.

### Present Plant and Process

The present furnace has an approximate overall height of 95 ft., and has inside lines specifically adapted to our experience in smelting phosphates. The maximum capacity of this furnace is in excess of 250,000 lb. of $P_2O_5$ per day. A model of the complete furnace plant is on exhibit at "A Century of Progress."

A special grade of muck phosphate rock from the Mt. Pleasant district of Tennessee, about 50 miles south of Nashville, is used. This rock is shipped dry in box cars to avoid paying freight on moisture. The rock is unloaded by power shovels into a skip hoist and dumped in a concrete silo from which it discharges into two mills located at the bottom of the silo. The pulverized rock from the mills is carried by a pneumatic conveyor to the top of the milled rock silo from which it discharges on a belt conveyor with sufficient pulverized coal to furnish approximately half of the carbon for theoretical reduction of the $P_2O_5$ present. The conveyor belt discharges into a mixer where a suitable binder is added. This mixture feeds into a set of briquet rolls where the briquets are formed under a pressure of approximately 5,000 lb. per sq.in. The briquets are dried to a moisture content of less than 1 per cent in a continuous dryer, and discharged into briquet storage bins.

Coke is shipped from the Chattanooga or Birmingham district, and is stored in bins similar to the briquet bins. Silica gravel is handled in another bin.

An electrically driven scale car with two bell-bottom buckets passes under the stock bins and collects one bucket of coke and one bucket of briquets, and a weighed amount of silica gravel, depending on the briquet silica and lime analyses. These buckets are carried up the skipway and dumped into the furnace.

Slag is tapped from the furnace hearth once an hour, and the ferrophosphorus formed from the iron impurities in the rock and coke is tapped every 12 hours.

The slag contains less than 2 per cent of $P_2O_5$ and is sold for railroad ballast or made into a special cellular product with the trade name of "Tufflite" which is used for insulating, and light-weight concrete aggregate.

The ferrophosphorus, containing over 24 per cent phosphorus, is converted into trisodium phosphate by a special patented process.

To get back to the furnace, we have the volatilized phosphorus, carbon monoxide, and nitrogen gases leaving the furnace top, and carrying dust and fume particles similar to those described in the review of our Chicago Heights experiments. This gas passes through a large dust catcher and a series of cyclone dust collectors and special fume collectors. The cleaned gas stream is then split three ways, one portion going to the phosphorus condensing plant where elemental phosphorus and anhydrous phosphorus pentoxide are prepared. A second portion is passed into special boilers for the generation of steam, and the third portion is burned in the four hot-blast stoves for heating the air blast supplied to the furnace hearth for combustion of the fuel coke.

The gaseous products of combustion from the boilers and stoves, containing $P_2O_5$ in fume form, are led into hydrating chambers where they are cooled and hydrated. These cooled gases are then drawn through a series of draft fans and distributed to the Cottrell electrical precipitators where condensation of the liquid phosphoric acid takes place. The acid condensed in these units ranges in strength from 85 to above 90 per cent ortho phosphoric acid, and has only to be diluted, treated for arsenic and filtered before it is ready for the market, or for use in making phosphatic salts or compounds. A large proportion of the acid produced is condensed in the hydrating chambers and at the fans. This acid is of about the same purity as the precipitator acid.

It is interesting to note that the acid now produced is almost a chemically pure product, far surpassing in quality our acid prior to the introduction of the furnace process. This is shown by the tabulated analyses.

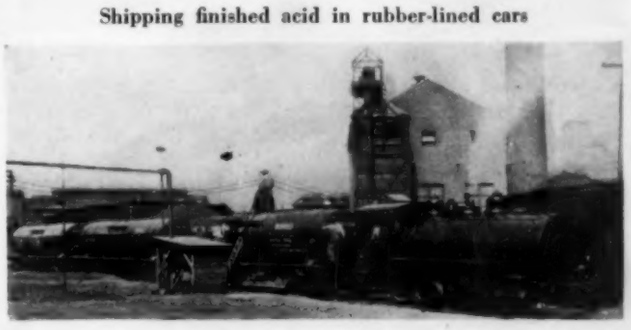
**Comparison of Blast-Furnace and Wet-Process Acid**

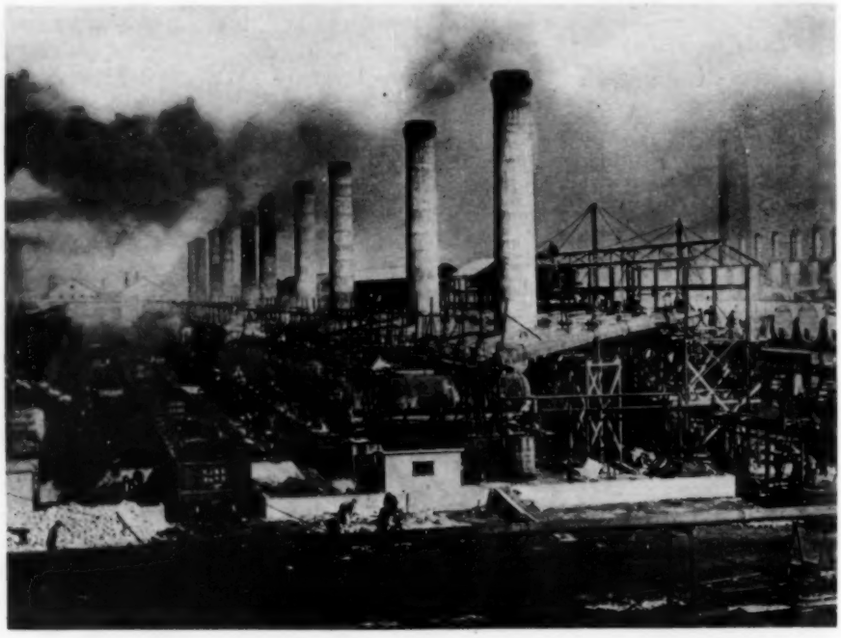
| | Blast Furnace Process | Wet Decomposition Process |
|---|---|---|
| Gravity, Deg. Bé | 54.2 | 51.0 |
| $H_3PO_4$, % | 75.65 | 64.88 |
| $P_2O_5$, % | 54.88 | 48.20 |
| Fe and $AlPO_4$, % | 0.13 | 1.35 |
| $SO_3$, % | 0.01 | 0.52 |
| Mn, % | 0.001 | 0.18 |
| Total bases, % | 0.60 | 5.00 |

It is also interesting that the phosphorus volatilization during the past year has averaged as high as 95 per cent and the $P_2O_5$ yield above 90 per cent of the $P_2O_5$ charged.

In conclusion, I would like to mention the names of Messrs. August Kochs, Rothe Weigel, and the late H. F. Noyes, whose untiring efforts and faith in the process have been largely responsible for its success.

**Shipping finished acid in rubber-lined cars**





Burton pressure stills of about 1920 in a refinery of the Standard Oil Co. of Indiana

A Foster-Wheeler 5,000-bbl., two-stage atmospheric vacuum pipe still

# CHEMICAL ENGINEERING PETROLEUM

A BOOK might well and should be written on the chemical engineering advances made in the petroleum industry during the depression years. No other field, outside of the strictly chemical industries, has accepted the chemical engineer on a comparable basis, or made better use of his ability. On the other hand, few other industries offer the widespread of opportunity, not only in the application of the unit operations but in the development of chemical processes affecting such a variety of raw materials and finished products. Therefore, in a brief reference here, we can give only a few scattered highlights to reflect the striking progress being made on so many fronts.

Even in the oilfields, the chemical engineer has found a place for himself in solving corrosion problems and in developing new chemical and physical methods of increasing the recovery of oil from the ground. Conservation is at once a result and a cause for stimulating this greater activity.

In the refineries, chemical engineering attention has centered largely in improvements in cracking and other distillation practices, in recovery of byproducts, in developing and applying radically new refining processes such as hydrogenation, in utilizing new agents and methods in chemical treatment, and in attacking and solving the multitude of corrosion problems.

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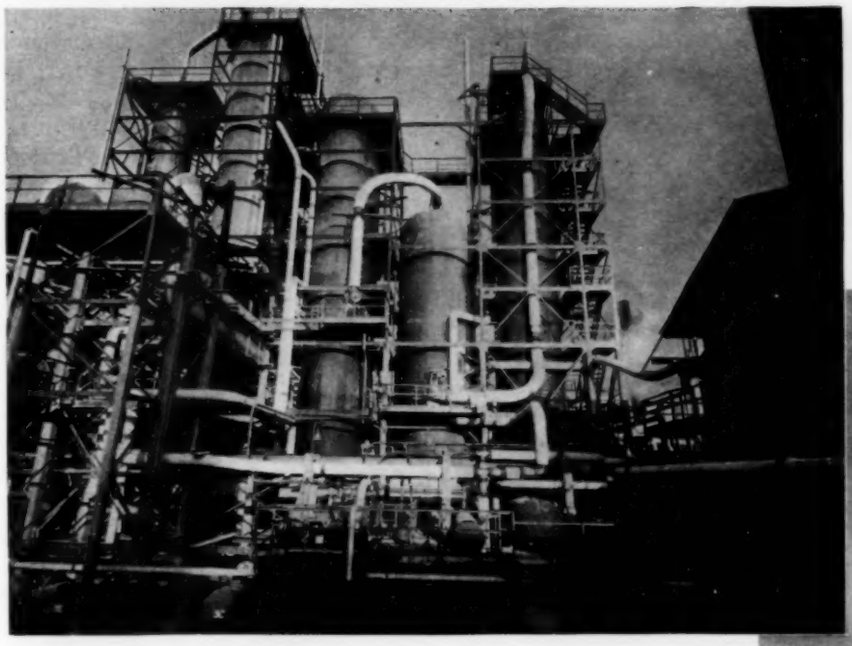
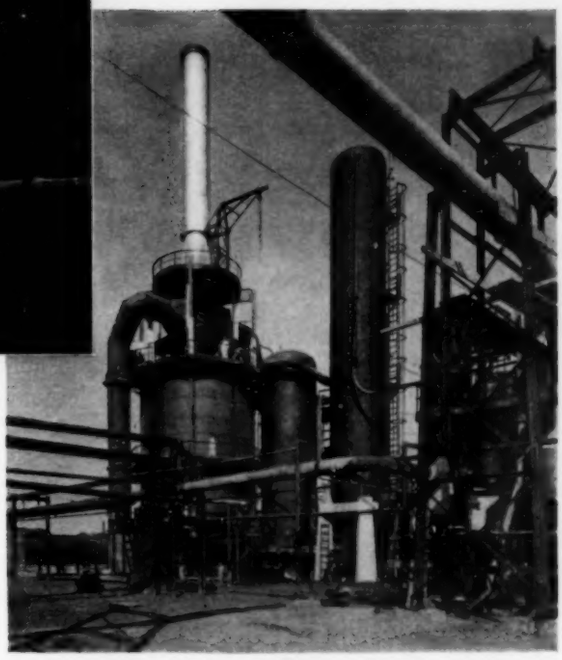
The photographs illustrating this editorial summary were supplied through the courtesy of H. W. Sheldon, chief chemical engineer of the research and development department of Socony-Vacuum. His chapter on petroleum refining appears in the Silver Anniversary Volume of A.I.Ch.E. just published by D. Van Nostrand & Co.



This combination cracking unit is the largest in operation today and will produce several times as much gasoline as all the Burton stills shown on the opposite page

A DeFlorez vapor-phase cracking unit in plant of the Standard Oil Co. of New York



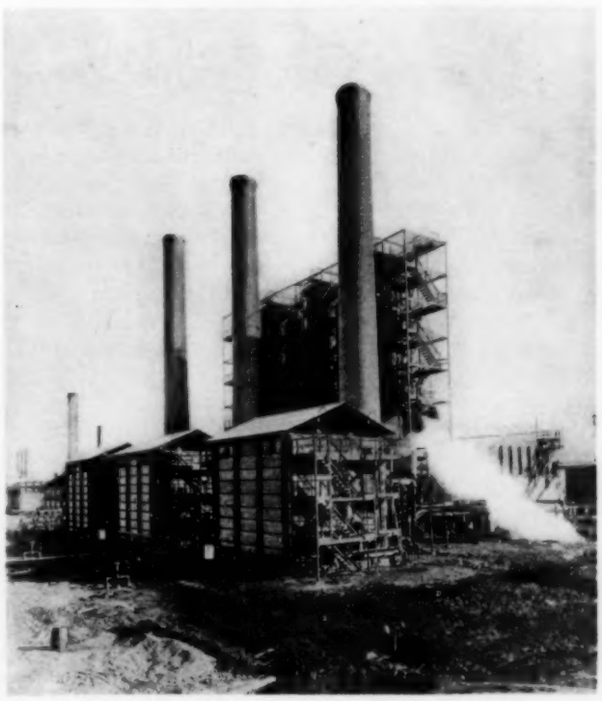
# ACHIEVEMENTS IN REFINING

A few examples will serve to recall some of the outstanding developments: Standard of Indiana in 1932 built the largest commercial cracking unit in the world, capable of completely processing 19,000 bbl. of charging stock per day. It is interesting to note that this is just about 100 times the size of Dr. Burton's largest cracking units of twenty years ago. The Vacuum Oil Co. of Paulsboro, N. J., first applied the pipe heater to vacuum distillation on a commercial scale in 1927 or 1928. Their two-stage atmospheric-vacuum unit had a daily capacity of 2,000 bbl. Today, most of the larger lubricating oil refineries have similar units but daily capacities have mounted to as high as 14,000 bbl. of crude oil processed.

Vapor-phase cracking, stimulated by the necessity for producing high anti-knock gasoline, has had its most rapid progress within the past two years. The Gyro process of Pure Oil, DeFlorez used by Texas and Gulf and the Pratt unit of the Lubrite Refining Corp. are perhaps outstanding examples. In all processes, heat conservation through improvements in furnace construction and equipment design have been reflected in important fuel economies.

Hydrogenation of petroleum made its first public bow in America through the pages of *Chem. & Met.* in June, 1929, after two years of chemical engineering research at Baton Rouge, La. The remarkable results achieved in the experimental and semi-works plant there led the Standard Oil Co. (N. J.) to erect two large-scale hydrogenation plants. In 1930, a 5,000-bbl.

Battery of three 10,000-bbl. Kellogg pipe stills which produce gasoline, naphtha, kerosene, gas oil, paraffin distillate and fuel oil continuously



per day unit commenced operations at Bayway, N. J., to be followed a year later by a similar plant at Baton Rouge. A hydro-refined lubricating oil, Essolube, was the first product to be widely marketed but the process has demonstrated its utility in producing special grades of kerosene, a safety airplane fuel, and a wide range of petroleum and chemical products. Here, it would seem, is a chemical engineering achievement of real merit.

Ethyl gasoline put a quality and performance question-mark in the minds of the motorist. The oil industry learned that its best customer was willing to pay a premium for a better product. So the same philosophy was shifted to lubricants and in recent years every progressive oil refinery in the country has been at work improving the quality of its motor oils. New processes and products have appeared in profusion. Probably Standard of Indiana led the way with its Iso-Vis, but it continued its research and has just announced two radically new processes. The first known as "propane dewaxing" uses liquefied petroleum hydrocarbons at pressures up to 200 lb. per sq.in. The pressure is gradually reduced and by adiabatic evaporation of part of the solvent, the solution is self-refrigerated to about —40 deg. F. which forces all of the wax to crystallize. This is removed by settling or filter pressing. The second process known as "chlorex extraction" utilizes a new selective solvent, dichloroethyl ether, for removing undesirable constituents from the base stock. Other comparable and perhaps equally important extractive processes include the use of nitrobenzol by Atlantic Refining, of phenol by Imperial Oil, Ltd., and trichlorethylene by Standard Oil of N. J.

Texas Pacific Coal & Oil Co. was one of the first to attack the problem of producing the extremely low cold test lubricating oils required for airplanes flying at high altitudes or for motoring under severe winter conditions. By a patented distillation process, Dr. E. R. Lederer produced a heavy bodied lubricant substantially free from wax and having a cold test below zero deg. F. and which without blending would remain fluid at temperatures as low as —30 deg. F. Attacking the problem from another angle, the research laboratories of Standard Oil of N. J. developed a new viscous synthetic hydrocarbon material of a paraffinic nature known as Paraflow. When blended, even in small percentages with wax-bearing oils, it greatly reduces the pour-point of the final product. By the end of 1932 it had been adopted by 90 per cent of the Pennsylvania refineries, and 80 per cent of those in the Mid-Continent.

In the field of chemical treatment, mention should be made of the Edeleanu process utilizing liquid sulphur dioxide, the Gray vapor-phase process utilizing fullers earth and, more recently, the Lachman process in which a zinc chloride solution is employed. The brucite sweetening process and the increasing use of sodium hypochlorite have been recent developments.

Of the byproducts that to an extent have become main products, leading place must be given to the liquefied petroleum hydrocarbons, whose output mounted from 1,091,005 gal. in 1927 to 33,630,236 gal. in 1932. Today 134 municipalities in 28 states are being served with this convenient fuel, while there are countless thousands of individual installations in homes and plants. The Knowles process of coking heavy refinery residuum, developed about three years ago in the refinery of the Tidewater Oil Co. at Bayonne and since rather widely adopted solves a very real problem and produces as useful byproducts, coke, gas, fuel oil and gasoline.

# Natural Gas Technology

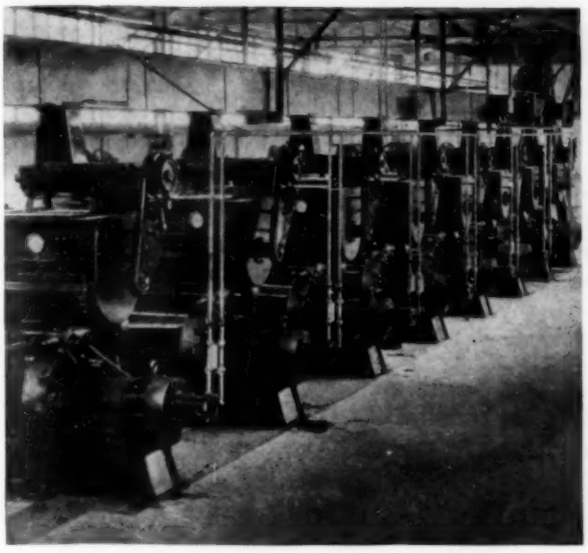
PROGRESS in this important field so closely allied to petroleum was recently reviewed before the Third Petroleum and Natural Gas Conference of Pennsylvania State College by George A. Burrell and Nelson C. Turner of the Burrell-Mase Engineering Co. The authors paid particular attention to the removal of hydrogen sulphide, which although not generally present in Appalachian natural gas, except from deep horizons, may reach a maximum of 10 per cent in certain Texas fields. Methods of removal most generally used include the old iron-oxide process, the lime process, the Girdler process employing a mixture of di- and triethanolamine and the Seaboard process of the Koppers Co., in which the hydrogen sulphide is removed with soda ash solution. In one refinery about 98 per cent removal is effected by this process from still gases containing 1,000 grams of $H_2S$ per 100 cu.ft. and the soda requirement is only 0.07 lb. per 1,000 cu.ft. of gas purified.

The most recent development is the Koppers hot activation process, in which the $H_2S$ is washed out of the gas with sodium phenolate solution made from caustic soda and tar acids. The foul solution is preheated in a heat exchanger and sent to the actifier, where the $H_2S$ is driven off by boiling with steam. It can be recovered in substantially pure form and may be readily burned to sulphur dioxide for sulphuric acid production.

No radical improvements have been made in natural gasoline plants in recent years; the greatest single advance is the introduction of rectifying columns (stabilizers) to remove wild fractions from the finished product. Control equipment has also been improved.

Refinery gases are produced in a volume of close to 600,000,000 cu.ft. per day, mainly from cracking stills in refineries. In contrast to natural gas they contain both unsaturated and saturated hydrocarbons, and some hydrogen. After treatment to extract the gasoline they are generally burned under refinery stills. Standard Oil Co. of New Jersey produces isopropyl alcohol from this gas, and Carbide and Carbon Chemicals Co. purposely crack oil in the vapor phase to produce a gas rich in unsaturated compounds from which glycols, ethyl alcohol, and other chemicals are made. Aromatics can be produced from natural gas at high temperature and with short time for heating—a cracking reaction similar to that used to make gasoline from heavier oils.

# Problems in Processing of Cottonseed Meats



**Modern expeller mill installation**

By W. R. WOOLRICH AND E. L. CARPENTER

*Respectively, Professor and Assistant Professor of Mechanical Engineering, University of Tennessee, Knoxville*

FOUR METHODS are available for the commercial production of cottonseed oil: Hydraulic pressing of the oil from the meats; expelling of the oil with the pressure expeller; solvent extraction; and finally release of the oil from the seeds by bacterial fermentation. Almost 100 per cent of the American production, which amounts normally to more than 1½ billion lb. annually, is separated either by mechanical compression or by expelling methods. This is remarkable when it is considered that even the best mechanical methods recover only 85 per cent of the available oil, as compared with a 95 per cent recovery readily obtainable with chemical extraction. The mechanical details of the chemical and fermentation methods have never been developed to a point to attract American oil millers.

From several standpoints it is desirable to extract a higher percentage of oil. The meal would keep longer with a lesser oil content; better extraction would yield more oil at no greater milling cost; and the resulting byproduct meal would be palatable, sweet and nutritious and desirable for human consumption, especially where a high-protein, almost starch-free flour is desired for the balancing of diets.

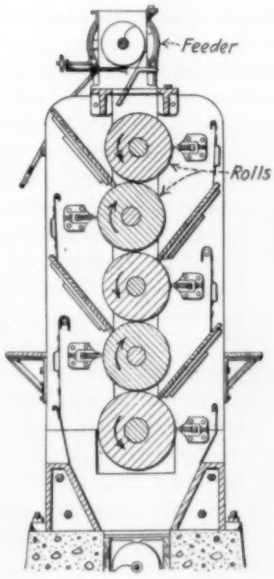
Cottonseed oil was produced commercially by cooking, followed by pressing, prior to 1830. Hence, the problem of obtaining high oil recovery is more than 100 years old. Many reasons have been assigned for poor and varying results, but the principal cause has been a lack of careful study of the conditioning, rolling and cooking of the meats. Control methods have been rule-of-thumb, the processes largely empirical and the fundamentals of good cooking and processing not fully known.

Abstracted and preprinted by permission from a paper to be presented before the process industries group of the A.S.M.E. at Chicago, June 29, 1933, under the title of "Factors and Problems in Conditioning, Cooking and Pressing Cottonseed Meats."

Probably the most important step in the preparation for cooking is the rolling operation. In a typical set of "five-high" rolls such as those illustrated, the cleaned meats are fed downward through succeeding pairs of rolls, in each pass of which they receive the combined weight of all the rolls above. For a number of generations, it has been a generally accepted theory that rolling actually crushed the oil cell to set free the oil. However, several score of rolled specimens examined by the authors under the microscope indicate that seldom is a cell ruptured in the rolling process. Even when the meats have passed through a second series of rolls, a practice followed in some plants, there is no evidence of a general breaking down of the cell structure.

Grinding to a very fine mesh has been substituted for rolling in some plants, but never with any uniform acceptance. Experiments indicate that the present rolling methods give oil yield equivalent to grinding even when the meats are ground to pass through a 50-mesh sieve. Microscopic examination indicates that the grinding operation is no more successful in breaking the oil cells than is rolling. Consequently, it appears that the real function of rolling is to expose a greater area of the meat to the subsequent treatments in the milling process.

**End section of cottonseed meat rolls**




After the meats have been rolled to a given fineness, the tempering with moisture, or what the oil miller terms "humidifying," must be performed. In commercial practice the meats are conditioned to contain about 12 per cent moisture when entering the cooker. When and how this moisture should be added and just what its function

is, is one of the debated questions in the industry. One school expresses the opinion that the moisture should be added in the seed house, while a second group proposes that the moisture should be added just after completion of the hulling operation and prior to rolling. But the general practice is to add the moisture just before the meats enter the cooker or to add water in the cooker itself. The first two methods cut down the dust loss but introduce problems in uniform moisture distribution. The last is evidently preferable.

### Steam for Conditioning

Experiments by the authors indicate that if moisture is added just before cooking and the seed brought up to 210 deg. F. with steam, the time required in the cooker itself can be reduced to a fraction of the present schedule. The steam used should be free from water as it enters the conditioning apparatus to insure a uniform product.

Observations based on the present state of our research indicate that the cooking operation has several functions. In the first place, it should be recognized as a drying process. Hence, the moisture addition should precede the cooking. The early belief that cooking assisted by making the oil "more limpid" is only partially true. Its viscosity is of course lowered, but the oil cannot run from the seed until the cell wall is broken. However, if the cells are properly processed with moisture, the walls become porous, thus offering a better outlet for the oil. Under certain conditions, it appears that the cell wall may even disintegrate in the presence of moisture. Furthermore, if the cells are heated rapidly to 230 deg. F. after processing with moisture, the steam generated within the cell will rupture its walls, permitting escape of the oil. The heating process congeals the proteins of the cell, assisting in the later filtering operation at the presses.

Cooking is accomplished in large steam-jacketed kettles stacked three to six chambers high. For the entrance and discharge of the meats, each chamber has openings equipped with gates in the top and bottom, and is provided with a pair of power-driven stirring arms for agitation and discharge. Meats are first fed into the topmost chamber from which, after an interval, they discharge to the next one below, and so on. The steam jackets comprise both the cylindrical side walls and the partitions between chambers.

Because of the high insulating character of cottonseed meats, rapid heat transfer cannot take place without efficient stirring. Without agitation, tests made in a miniature cooker in our Engineering Experiment Station showed very slow heat transfer from the jacket wall held at 210 deg. F. With the meats at an initial temperature of 80 deg., the temperature after 30 min. at a point 1 in. inside the jacket was 158 deg., and at 6 in. only 82 deg. How effective present stirring arms are is a matter for further research. It has been shown that a period of 10 to 20 min. at 230 deg. F. would suffice for the cooking if all the meats were maintained at that temperature, but present practice is to hold the meats in the cooker from 1 to 2 hours. Even with this, microscopic examination of the meal reveals some cells unbroken.

To speed up cooking, many plants maintain a jacket temperature as high as 287 deg. However, since the oil darkens at temperatures above 230 deg., it is a doubtful procedure to employ a temperature of 287 deg. with a material that is a very good insulator, and with stirring that is only partially effective.

Two methods may be useful in improving cooking. One is to condition the meats with dry steam, raising their temperature to 210 deg. in the tempering process. The other is deliver the meats to the top cooking chamber with sufficient moisture, but at room temperature, and to employ such effective agitation in this chamber that the temperature is raised to 220-230 deg. so that the remaining chambers need only to hold the temperature gained in the first. In either case, the total time in the cooker and the amount of heat required to rupture the cells, dry the meats and coagulate the proteins would be small.

Off-hand it might appear that continuous rotary cookers would solve the problem. Due to balling up and consequent incomplete cooking with the present variable conditioning procedure, revolving cookers have not been satisfactory. However, with positive control of the conditioning process, such equipment might be a success. If these principles could be successfully introduced, our experiments have shown that the cooking time could be reduced to 10 min.

It is generally accepted that a moisture content of 12 per cent on the total weight of the meats is most desirable from the standpoint of both crude oil production and of refining loss. The preliminary test in our laboratories shows this to be somewhat low, but consideration must also be given to the increase in refining loss if the moisture content is made too high. We are at present determining the effect of varying moisture content, using a continuous cooker and special conditioning chamber and holding all other conditions constant.

### Expeller Mill Processing

Preliminary milling operations in an expeller mill are identical with those in a hydraulic compression plant. Meats are hulled, course ground and dried, for uniformity, to 3 per cent moisture. In a tempering conveyor they are slightly heated and moistened with enough water to act as a lubricant in the expeller. They are then conveyed by a vertical worm feeder, equipped with a solid worm flight, to a horizontal pressing cylinder in which are intermittent worms of progressively smaller pitch, all on the same shaft. The enclosing cylinder is made up of heavy bars between which the oil is expressed. The cake, which is readily ground into meal, is forced from the end of the cylinder. Each expeller will remove the oil from 10 to 15 tons of meats per 24 hours.

The major unsolved problem today in the mechanical production of cottonseed oil is the improvement of oil yield and of meal quality by better processing methods and control. When it is considered that the value of a normal year's milling approaches a quarter million dollars, the importance of the project is commanding. In solvent production, the major unsolved problems are likewise mechanical rather than chemical, consisting in the lack of commercially developed continuous extractors, limitations of present filtering methods, and the unsatisfactory distillation and recovery of solvents. Nevertheless, such are the inherent advantages of the solvent process that mechanical methods must be the subject of a decade of vigorous research if they are to retain the near-monopoly they have enjoyed in the past.

# Vinyl Plastics From Carbide

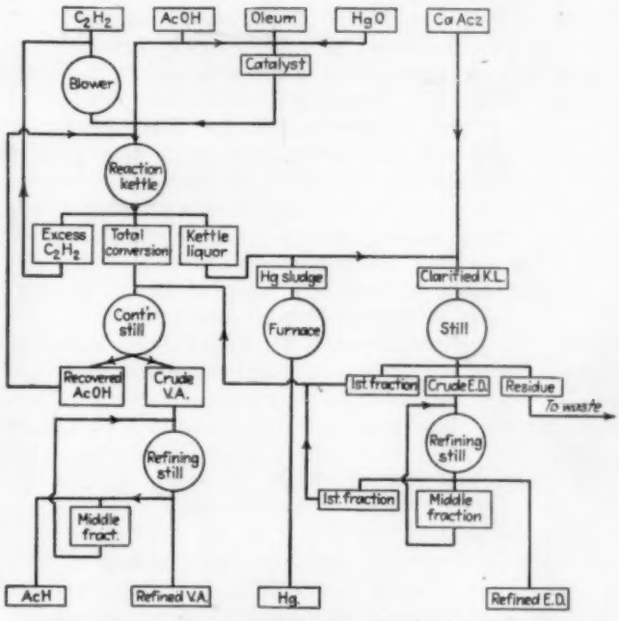
By GEORGE O. MORRISON
and
T. P. GLADSTONE SHAW
*Shawinigan Chemicals, Ltd. Montreal*

DURING THE WAR period of 1914-18 little work was done anywhere on ethylidene diacetate and vinyl acetate, but immediately thereafter the rapid development of cellulose acetate with its demand for acetic anhydride resulted in an increased interest in the production of ethylidene diacetate. Late in 1917 the Shawinigan Chemicals, Ltd., started a study of the acetylene-acetic acid reaction, but no serious attempt was made to make use of this reaction to produce vinyl acetate until some years later.

The process for the manufacture of ethylidene diacetate consists of the passage of acetylene into glacial acetic acid in the presence of a suitably prepared mercury sulphate catalyst; the reaction is generally written $C_2H_2 + 2CH_3COOH = CH_3CH:(O.CO.CH_3)_2$. The early work showed that finely ground mercury sulphate gave no reaction on the passage of acetylene and that this salt must be prepared from acetic acid solution by precipitation with sulphuric acid in some form. Concentrated sulphuric acid did not give satisfactory results, which was attributed to the water formed in dissolving the mercury oxide. The process was greatly improved by the use of oleum, the $SO_3$ of which combines with the water. Much work was done in comparing the use of oleum of various strengths, sulphuryl chloride, and $SO_3$ in the preparation of the catalyst; 70 per cent oleum and $SO_3$ proved greatly superior to any other precipitants, increasing the percentage conversion and the yields of acetylene and acetic acid. The excess of precipitant proved to be of great importance, having a marked effect in increasing the reaction speed and percentage of conversion; about 1 per cent excess precipitant, based on the kettle charge, proved to be the most suitable.

It was found that the kettle material had a marked effect on the amount of catalyst necessary. With enamel ware, Duriron, or stainless steel about 2.5 per cent mercuric oxide or 4 per cent mercurous oxide gave satisfactory conversions. In the latter case the most suitable excess of precipitant was found to be about 2 per cent. Certain other factors were also found to influence the production of ethylidene diacetate; the most suitable temperature was 70 to 90 deg. C.; circulation rate was not critical, but had a certain effect on the time of run and the conversion of acetic acid to ethylidene diacetate. Using circulated acetylene instead of mechanical agitation in a tall narrow kettle the circulation should be held above a certain definite minimum.

The ethylidene diacetate as prepared in the first stage must be purified. After removal of the spent mercury catalyst the most advantageous method for destroying the mineral acid was found to be addition of a suitable amount of sodium or calcium acetate. The material was separated from the tarry matter and salts in a vacuum still equipped with an agitator and finally vacuum fractionated to the required purity.




**Flow sheet giving essential steps in the vinyl acetate-ethylidene diacetate process.**

Patent covering this phase of the work was applied for in 1920, by Shirrow and Matheson (U.S. Patent 1,720,-184). The only other patents appearing about this time were those of Koetschet and Beudet (U.S. Patents 1,304,989 and 1,306,964) on the use of methylene sulphate, sulphuric acid, and sulphoacetic acid with mercury salts in preparation of the catalyst.

The early results showed that appreciable quantities of vinyl acetate were obtained as a side reaction product, confirming Klatte's earlier findings. This, in spite of the fact that low circulation rates were used and the kettle was run under total reflux in order to keep the vinyl acetate at a minimum. In the decomposition of ethylidene diacetate to acetic anhydride and acetaldehyde, small quantities of vinyl acetate were also obtained as a byproduct. This was converted to ethylidene diacetate by reaction with acetic acid in the presence of acid catalysts.

An attempt was made in 1921 to increase the yield

Abstracted from the original paper which was presented by Mr. Morrison before the Montreal meeting of the Electrochemical Society, May 12, 1933, and will be published in full in the *Transactions* of the organization.

of vinyl acetate by increasing the circulation of acetylene through an incomplete ethylidene diacetate conversion, separating the vinyl acetate from the excess gas and drawing it off, instead of refluxing it to the conversion kettle. Thus the yield of vinyl acetate was increased about threefold. In 1924 small quantities of vinyl acetate were prepared by a modified ethylidene diacetate process, with higher circulation rates, lower kettle temperatures, and with removal of the total condensate. The yield so obtained was 61.2 per cent of the acetic acid reacted, appearing as vinyl acetate. This idea of using higher circulation rates of acetylene to remove the vinyl acetate from the reaction zone was incorporated in Canadian Patent No. 237,841 of February, 1924; the method was similar to that employed for over 10 years in this plant for the removal of acetaldehyde from kettle liquor. This same idea was covered in Canadian Patent No. 264,158 of September, 1926. (Consortium f. elek. Ind. Ges.)

In 1925 inquiries for vinyl acetate led to more serious study of the conditions for its production. In previous work, yields of 60 to 77 per cent had been obtained on the acetic acid disappearing, with a per cent reaction of 40 to 50 per cent and optimum temperature 40 to 50 deg. C.; the catalyst was a mercury salt made *in situ* from mercury oxide and oleum, and high circulation rates for the removal of vinyl acetate were the conditions indicated in this early work. The investigation was now turned to a study of other catalysts, such as mercuric acetate, mercuric sulphate (not made *in situ*), mercury phosphate (made *in situ*), and the regular ethylidene diacetate catalysts. Both the effect of excess oxide and excess acid were tried. The first two types of catalysts gave little or no vinyl acetate.

Ortho-phosphoric acid catalysts were unique in that the acetic acid reacted was almost quantitatively converted to vinyl acetate. The standard procedure used in these runs was to dissolve 3 per cent mercuric oxide in glacial acetic acid at 80 to 90 deg. C., adding 2.4 per cent of 100 per cent ortho-phosphoric acid with good agitation, or sufficient to form $Hg_3(PO_4)_2$ and leave 1.5 per cent free phosphoric acid. It was found that meta-phosphoric and pyro-phosphoric acid gave high ethylidene diacetate runs, whereas with ortho-phosphoric acid, free from these materials, the source or concentration had but little effect and vinyl acetate alone was produced. Optimum temperature was found to be 70 to 75 deg. C. and the circulation rate, although not critical, was kept sufficiently high to remove the vinyl acetate.

These results showed that it was possible to design a catalyst which would give essentially vinyl acetate with little or no ethylidene diacetate as a byproduct. Catalyst cost was high, due to the low output per pound of HgO, the use of an expensive catalyst acid, and the low rate of conversion. In the older work with oleum catalysts, although both ethylidene diacetate and vinyl acetate were obtained, the output per pound of oxide and the rate of conversion were higher and the catalyst acid was less costly. The next work reverted to the study of these older sulphuric acid and oleum catalysts.

Work with batch vinyl acetate runs using sulphuric acid and oleum catalysts was started with the study of catalysts made by using 95 per cent sulphuric acid and was systematically followed through to the use of the higher oleums. Many factors influencing the catalytic action were examined, such as type and excess of catalyst acid, quantity of catalyst used, and method of making the catalyst. Results of typical runs in this study given in Table I serves to illustrate the grounds for the following discussion and conclusions.

These catalysts, known to be ethylidene diacetate catalysts, produce a considerable quantity of this product along with the vinyl acetate. Output of vinyl acetate per pound of oxide using sulphuric acid was no higher than that obtained with phosphoric acid, and the yield of vinyl acetate on the acetic acid reacted was considerably lower. With oleum catalysts, on the other hand, the output of

**Table I—Batch Vinyl Acetate Runs. Data of Typical Sulphuric Acid and Oleum Catalysts**

| Run No. | Catalyst: Per Cent HgO | Catalyst: Acid Used | Catalyst: Excess Acid as $H_2SO_4$ | Remarks | Circulation Cu.Ft./Hr. | Temp. °C. | Calc. Yield on Acetic: E. D. % | Calc. Yield on Acetic: V. A. % | Calc. Yield on Acetic: $Ac_2O$ % | Yield $C_2H_2$ as V. A. % | Lb. V. A. Per Lb. HgO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 201 | 3.0 | 95% $H_2SO_4$ | 0 | ..... | 25 | 50–60 | 28.6 | 71.4 | .... | 58.9 | 10.0 |
| 203 | 3.0 | 95% $H_2SO_4$ | 0 | ..... | 40 | 45–60 | 22.8 | 77.2 | .... | 57.0 | 10.1 |
| 346 | 3.0 | 100% $H_2SO_4$ | 1.5 | ..... | 50 | 45–60 | 43.5 | 44.6 | 11.9 | 50.7 | 10.6 |
| 347 | 3.0 | 100% $H_2SO_4$ | 1.5 | 70% oleum for excess. | 50 | 45–60 | 31.3 | 49.8 | 18.9 | 65.1 | 13.4 |
| 348 | 3.0 | 70% oleum | 1.5 | 100% $H_2SO_4$ for excess. | 50 | 45–60 | 16.0 | 61.2 | 22.8 | 70.9 | 19.4 |
| 321 | 3.0 | 60% oleum | 0 | Excess oxide. | 50 | 45–60 | 25.2 | 74.8 | .... | 61.7 | 10.1 |
| 319 | 3.0 | 60% oleum | 0 | ..... | 50 | 45–60 | 21.0 | 79.0 | .... | 65.0 | 14.5 |
| 318 | 3.0 | 60% oleum | 0.75 | ..... | 50 | 45–60 | 20.0 | 77.2 | 2.7 | 69.3 | 24.8 |
| 317 | 3.0 | 60% oleum | 1.5 | ..... | 50 | 45–60 | 14.5 | 74.8 | 10.7 | 76.2 | 38.1 |
| 320 | 3.0 | 60% oleum | 2.3 | ..... | 50 | 45–60 | 15.8 | 74.0 | 10.2 | 71.7 | 34.3 |
| 325 | 3.0 | 60% oleum | 10.0 | ..... | 50 | 45–60 | 88.7 | 4.1 | 7.2 | 5.3 | 1.7 |
| 327 | 1.0 | 60% oleum | 1.5 | ..... | 50 | 45–60 | 32.7 | 65.7 | 1.6 | 65.6 | 46.3 |
| 328 | 6.0 | 60% oleum | 1.5 | ..... | 50 | 45–60 | 24.6 | 71.0 | 4.4 | 70.5 | 24.1 |
| 345 | 3.0 | 70% oleum | 1.5 | ..... | 50 | 45–60 | 25.7 | 74.3 | 0 | 77.1 | 45.9 |
| 378 | 1.0 | 75% oleum | 1.5 | Cat. made at 25° C. | 50 | 28–48 | 26.2 | 62.0 | 11.8 | 76.7 | 21.9 |
| 382 | 1.0 | 75% oleum | 1.5 | Cat. made at 85° C. | 50 | 26–48 | 22.8 | 77.2 | .... | 75.5 | 101.9 |
| 384 | 1.0 | 75% oleum | 1.5 | Oleum dil. with acetic acid. | 50 | 29–48 | 27.5 | 72.5 | .... | 70.0 | 108.1 |

**Table II—Continuous Vinyl Acetate Runs. Data of Typical Continuous Runs**

| Run No. | Initial Catalyst: Per Cent HgO | Initial Catalyst: Acid | Per Cent Excess Acid | Duration Hr. | No. of Cat. Feeds | Temp. °C. | Circ. Cu. Ft. /Hr. | Calc. Yield on AcOH: E. D. % | Calc. Yield on AcOH: V. A. % | Calc. Yield on AcOH: $Ac_2O$ % | Yield of $C_2H_2$ as V. A. % | Make Lbs. V. A./Lb. HgO | Per Cent AcOH Converted to V. A. | Lb. Kettle Liquor Drawn /Lb.V.A. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 3.0 | 60% oleum | 0.1 | 45 | 6 | 47–56 | 30 | 24 | 76 | ... | 50.7 | 10.5 | 40 | 1.3 | (1) |
| 128 | 3.0 | 98% $H_3PO_4$ | 1.5 | 11 | 2 | 72 | .. | 11.5 | 88.5 | ... | 60.4 | 8.9 | .... | .... | .... |
| 314 | 3.0 | 60% oleum | 1.5 | 100 | 14 | 45–60 | 50 | 15.5 | 76.2 | 8.3 | 77.1 | 38.4 | 46 | 0.6 | .... |
| 0–8 | 1.0 | AcOH—$SO_3$ | 1.5 | 41 | 4 | 46 | 30 | 17.3 | 80.3 | 2.4 | 60.1 | 78.9 | 66 | 0.18 | (2) |
| 389 | 1.0 | AcOH—$SO_3$ | 1.5 | 70 | 8 | 30–48 | 50 | 19.7 | 78.3 | 2.0 | 77.0 | 88.6 | 76 | 0.2 | .... |
| 401 | 1.0 | AcOH—$SO_3$ | 1.5 | 100 | 11 | 30–48 | 50 | 20.6 | 79.3 | 0.1 | 70.9 | 107.5 | 75.4 | 0.16 | .... |
| 0–19 | 1.0 | AcOH—$SO_3$ | 1.5 | 352 | 69 | 30–50 | 30 | 25.5 | 74.5 | ... | 69.1 | 78.8 | 72.5 | 0.48 | (3) |

(1) First cont. run. (2) Early pilot plant run. (3) Pilot plant run.

**Table III—Batch Runs Giving Higher Ethylidene Diacetate Formation**

| No. | Catalyst: Per Cent HgO | Catalyst: Per Cent Excess Acid as $H_2SO_4$ | Temp. °C. | Type | Calc. Yield on AcOH: E. D. % | Calc. Yield on AcOH: V. A. % | Yield of $C_2H_2$ as: E. D. % | Yield of $C_2H_2$ as: V. A. % | Make Per Lb. HgO: E. D. | Make Per Lb. HgO: V. A. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L-3 | 1 | 1.5 | 60–85 | Total reflux.... | 91.7 | 8.3 | 69.3 | 12.6 | 170 | 18 | (1) |
| E-8 | 1 | 1.5 | 60–85 | Total reflux.... | 97.6 | 2.4 | 79.0 | 5.6 | 158 | 6.6 | (2) |
| E-12 | 1 | 1.5 | 50–85 | V. A. separated | 79.2 | 20.8 | 50.1 | 26 | 124 | 38 | (3) |
| B-56 | 1 | 1.5 | 40–70 | V. A. separated | 44 | 56 | 26.1 | 56.3 | 67 | 108 | (4) |

(1) Lab. run. (2) Pilot plant run. (3) Pilot plant run. (4) Lab. run.

vinyl acetate was definitely much higher than with either the sulphuric or phosphoric acid catalysts and the yield of vinyl acetate was, if anything, better than with sulphuric acid. Anhydride formation was much lower with oleum than with the sulphuric acid catalysts. By raising the $SO_3$-content of the oleum, better all-round results were obtained.

By varying the excess of oleum the optimum region was found to be about 1.5 per cent excess acid. With 10 per cent excess oleum practically no vinyl acetate was obtained, the reaction having definitely passed over into the ethylidene diacetate type of run. Excess oxide or neutral conditions were distinctly worse than where excess acid was used.

A lowering of the per cent oxide generally increased the output of vinyl acetate per pound of oxide. Rate of output becomes higher with increasing percentage of oxide, although not in direct proportion. Yield of vinyl acetate on acetic acid reacted did not depend in any marked degree on the concentration of oxide.

In runs prior to No. 378 the catalyst was made at 70 to 75 deg. C. In runs Nos. 378 and 382 the temperature at which the catalyst was made varied widely and they showed the remarkable influence of the temperature in the precipitation of the catalyst. The much more active catalyst obtained at 85 deg. C. led to the use of lower run temperatures and permitted a reduction in the amount of oxide to 1 per cent. This newer technique led to the remarkable output of over 100 lb. of vinyl acetate per pound of oxide. In all except one run the catalyst was made by adding the mineral acid directly to the solution of the mercuric oxide in acetic acid. However, in run No. 384, the mineral acid was diluted with acetic acid before it was added to the mercuric oxide solution; this gave some improvement in the output.

### Catalysts

The results obtained showed definitely that improvements were effected by increasing the $SO_3$-content of the catalyst acids; this definitely pointed to the use of $SO_3$ itself. In the early ethylidene diacetate work such catalysts were tried with considerable success. When $SO_3$ is passed into glacial acetic acid, acetyl sulphuric acid, acetyl sulphoacetic acid, or sulphoacetic acid as well as small quantities of other compounds are formed, according to the temperatures used (Peski, Rec. trav. chim., 50, 103). At low temperatures acetyl sulphuric acid predominated; on heating this was partly changed to sulphoacetic acid, with poor yield, however, as many side reactions occur. This transformation was not very rapid below 70 deg. C. Thus AcOH-$SO_3$ made at low temperatures was essentially an acetyl sulphuric acid solution in acetic acid, while that made at high temperatures, around the boiling point of acetic acid, was believed to be largely sulphoacetic acid.

These acetic-sulphuric acid compounds may be made in several ways—by passing $SO_3$ into glacial acetic acid, by adding oleum to a mixture of acetic acid and anhydride, or by the reaction of sulphuric acid and anhydride. It was soon found that the use of $SO_3$ or oleum high in $SO_3$ gave very much better results than the other methods. Naturally $SO_3$ was chosen in the early work for the preparation of the complex mixture which we term AcOH-$SO_3$. As it was known that the temperature used in the preparation of AcOH-$SO_3$ affected the proportions of the components, its effect on the activity of the catalyst was one of the first points investigated. The work progressed from this to the temperature for the precipitation of the catalyst, and to other factors influencing the run, such as circulation, kettle temperature, and amount of catalyst.

### Work of Peski

A comparison of some of our runs shows that they do not all agree with the work of Peski, as in all cases acetyl sulphuric should be the catalyst acid. An interesting point is that an analysis for sulphate does not distinguish between acetyl sulphuric acid and mixtures of sulphuric and acetic acid or anhydride. Anhydride was not necessary when oleum or $SO_3$ was used in preparing the catalyst acid as glacial acetic gave equally good results. Ease of handling, improved output, and less critical catalyst precipitation temperatures led to the adoption of AcOH-$SO_3$. The temperature of preparation was important; lower temperature generally gave greater activity of the catalyst, showing that mixtures rich in acetyl sulphuric acid were superior to those made at high temperatures which presumably are rich in sulphoacetic acid. A temperature of 40 to 50 deg. C., well below the point at which rapid transformation to sulphoacetic acid is said to occur, was chosen as most desirable.

An increased excess of free catalyst acid gave a higher output of vinyl acetate with but slightly lower yields of acetylene and acetic acid as vinyl acetate. Excesses above 2 per cent were not explored, as they are not suitable for continuous runs; optimum excess for batch runs appeared to be about 1.5 per cent. With increasing oxide the output of vinyl acetate decreased sharply, while the rate of production was increased and a balance must be struck between the capacity of the unit and the cost of the catalyst.

Due to the rapidity with which the vinyl acetate reacts with acetic acid, under kettle conditions, to give ethylidene diacetate, higher circulation rates with more rapid removal of the vinyl acetate greatly improved output and yields. Again a balance must be struck between the

catalyst cost and cost of processing—circulation, condensation, and distillation.

Temperature control in the early part of a vinyl acetate run should be such that large gas absorptions are avoided. In the later stages the temperature is not nearly so critical provided one keeps below the range most suitable for ethylidene diacetate formation. Optimum vinyl acetate range during the latter stages was 50 to 60 deg. C. The influence of the purity of the raw materials was thoroughly investigated and it was found that ordinary commercial acetylene and glacial acetic acid were entirely satisfactory. Materials for much of the equipment were also studied by batch runs. With the exception of the kettle and its feed lines, resistance to corrosion was the essential requirement. For the kettle, enamelware, Duriron, or stainless steel was satisfactory.

The advantage of a continuous vinyl acetate process was apparent from the moment it was realized that the vinyl acetate formed should be removed continuously by the circulating acetylene, with a continuous still separating the vinyl acetate from the unreacted acetic acid. Another advantage is that batch runs give a relatively low conversion, leaving a kettle liquor from which must be recovered its acetic acid and ethylidene diacetate content.

In a completed batch run the kettle liquor contained spent catalyst and some free mineral acid. For a continuous run the conditions for addition of fresh catalysts and the adjustment of excess acid had to be determined. The first attempt was to add fresh catalyst to a spent liquor after settling out the mercury sludge; this run showed sufficient activity to insure the feasibility of the continuous process. Conditions were worked out for the earliest types of oleum catalysts and checked on all subsequent catalysts. Data from a few typical continuous runs given in Table II showed that production of vinyl acetate by a continuous process was entirely practicable. Continuous conditions were maintained by removal of a portion of the kettle liquor and by addition of fresh catalyst. Withdrawal of kettle liquor was employed to remove the ethylidene diacetate and spent catalyst from the system and to maintain unreacted acetic acid and free mineral acid at the required concentration. Figures for output and yield compared favorably with those obtained with similar catalysts under batch conditions. One of the great advantages was the increased per cent conversion of the acetic acid which was almost completely converted into ethylidene diacetate or vinyl acetate.

### Ratio of Vinyl Acetate to Ethylidene

The two most important factors governing the ratio of vinyl acetate to ethylidene diacetate are vinyl acetate removal and the temperature conditions during the run. By varying these factors a whole series of different ratios should be possible. Two general types of reactions were studied, total reflux conditions, and conditions for removal of vinyl acetate. Some typical runs are shown in Table III.

As expected the AcOH-$SO_3$ type proved to be a remarkably efficient ethylidene diacetate catalyst. It was also evident that either one or both of the esters could be produced in the desired ratio by essentially the same process and that the AcOH-$SO_3$ type of catalyst gave uniformly excellent results throughout the entire range.

**Table IV—Physical Data on Vinyl Acetate and Ethylidene Diacetate**

| Property | Vinyl Acetate | Authority* | Ethylidene Diacetate | Authority* |
|---|---|---|---|---|
| Molecular weight | 86.05 | 1933 | 146.08 | 1933 |
| Freezing point deg. C | below —84 | S. C. | 18.85° C. | S. C. |
| Boiling point deg. C | 73 | S. C. | 166** | S. C. and Ref. (4) |
| | | | 169 | Meyer & Jacobson |
| Specific gravity $\frac{20}{20}$ | 0.9342 | S. C. | 1.0742 | S. C. |
| Refractive index $n_d^{20}$ | 1.3958 | S. C. | 1.4012 | S. C. |
| Flash point (open cup) deg. C | —5 to —8 | S. C. | — | |
| Coeff. of cubic exp. 5–25° C | 0.00155 | S. C. | 0.00104 | S. C. |
| Viscosity 20° C | 0.432 c'poises | S. C. | — | |
| Heat of combustion: | 495 | Calc. | 624.7 | Calc. (Kharasch) |
| Kg. cal. per g. mol. | | | 697 | S. C. |
| Heat of formation: Kg. cal. per g. mol. | | | | |
| $C_2H_2$ + AcOH—V. A. | +28.3 | Calc. S. C. | — | |
| $C_2H_2$ + 2AcOH—E. D. | —— | | +34.5 | Calc. S. C. |
| V. A. + AcOH—E. D. | —— | | + 6.2 | " " |
| $Ac_2O$ + AcH—E. D. | —— | | + 1.4 | " " |
| Latent heat of vaporization | 7.8 | Calc. S. C. | 11.2 | " " |
| Kg. cal. per g. mol. | | | | |
| Solubility in water 20° C. | 2.5% | S. C. | 5.0 | S. C. |
| Solubility of water in ester 20° C | 0.1% | S. C. | 5.0 | S. C. |

* S. C.—Data accumulated in the Laboratories of the Shawinigan Chemicals Ltd., by W. R. Elliot, K. G. Blaikie, C. C. Coffin, and the authors.
** With possible slight decomposition.

Development of a practicable plant process including the necessary recovery systems was undertaken simultaneously to the catalyst work; the essentials of such a process are given in Fig. 1. This flow sheet may be divided into four systems—the catalyst-kettle-circulation system; the vinyl acetate system; the ethylidene diacetate system; and the mercury recovery system.

The first of these consisted of a unit for making the catalyst, a reaction kettle, and a unit for the circulation of acetylene. This system remained the same for the production of vinyl acetate, ethylidene diacetate, or both, with the exception that for ethylidene diacetate the total condensate was refluxed to the kettle.

The second system included the continuous still which separated the condensate into crude vinyl acetate and acetic acid which was returned to the kettle system. In the refining still the crude vinyl acetate was separated into an acetaldehyde fraction, middle fractions for redistillation, and refined vinyl acetate; the residue, chiefly acetic acid, was returned to the kettle. The capacity of this system varied according to the ratio of the esters produced; if ethylidene diacetate were the sole product, it might be eliminated, the vinyl acetate being converted into ethylidene diacetate.

In the ethylidene diacetate system which handled the kettle liquor, the mercury sludge was removed and an acetate added to combine with the mineral acid. A vacuum still equipped with an agitator separated this liquor into a "first fraction," returned to the continuous still, crude ethylidene diacetate, which was subjected to vacuum fractionation, and a dry residue going to waste. Capacity of the system varied with the ratio of the esters produced; if vinyl acetate were the only product desired, the system could be modified to hydrolyze the crude ethylidene diacetate, returning the acetic acid to the kettle.

The mercury recovery system, which was the same for all processes, consisted of a simple distillation furnace which could be modified to permit the destruction of the organic matter by combustion.

The processes outlined were conducted on a pilot plant scale; the present large plant designed on the results obtained has operated successfully without essential changes in process or equipment.

It is believed that the reaction between acetylene and acetic acid produces vinyl acetate and that ethylidene diacetate formation results from the reaction of this vinyl acetate with acetic acid.

1. $C_2H_2 + CH_3COOH = CH_2:CH.OCO.CH_3$ vinyl acetate.

2. $CH_2:CH.OCO.CH_3 + CH_3COOH = CH_3.CH.(OCO.CH_3)_2$ ethylidene diacetate.

This statement is supported by the following observations: More rapid removal of vinyl acetate from the reaction medium results in decreased ethylidene diacetate formation; return of vinyl acetate to the reaction medium, either in the recovered acetic acid or by the use of total reflux on the kettle, results in increased formation of ethylidene diacetate at the expense of vinyl acetate; catalysts are known which produce vinyl acetate with little or no ethylidene diacetate; reaction 2 has been used to prepare ethylidene diacetate; the reaction of ethylidene diacetate with acetylene, to produce vinyl acetate at moderate temperatures, has been attempted, but without success; reaction 2 is known to be reversible as some vinyl acetate and acetic acid are formed in the decomposition of ethylidene diacetate to acetic anhydride.

The data from results obtained in these laboratories refer to ethylidene diacetate of 99.7 per cent purity, the balance being acetic acid, and to vinyl acetate of 99.95 per cent purity.

Table IV gives general data for both esters. The agreement between these figures and isolated data for vinyl acetate given in the literature is good; for ethylidene diacetate the agreement is also good except for specific gravity and boiling point. The specific gravity (0.852) given on p. 201, Vol. 1, of the International Critical Tables is obviously wrong. Due to rapid decomposition of ethylidene diacetate when heated, an accurate determination of the boiling point is difficult. We feel that our figure, 166 deg. C., is low and favor the higher figures given by the early investigators.

**Table V—Vapor Pressure Data***

| Temp. ° C. | Vinyl Acetate Mm. Hg. | Ethylidene Diacetate Mm. Hg. |
|---|---|---|
| —10 | 19 | — |
| 0 | 30 | — |
| 10 | 53.5 | — |
| 20 | 90 | — |
| 30 | 145 | — |
| 40 | 220 | |
| 50 | 332 | |
| 58 | — | 12** |
| 60 | 485 | — |
| 70 | 683 | 17 |
| 80 | 940‡ | 27 |
| 90 | 1,290‡ | 45 |
| 100 | 1,723 | 74 |
| 110 | 2,255‡ | 113 |
| 114 | —— | 114*** |
| 120 | 3,055‡ | 170 |
| 130 | 3,580‡ | 243 |
| 140 | —— | 340 |
| 150 | —— | 472 |
| 160 | —— | 635 |

*Data from laboratories of the Shawinigan Chemicals, Ltd., except where other reference is noted.
**Wohl & Maag, Ber. 43,3293 (1910).
*** Wohl & Mylo, Ber. 45,329 (1912).
‡ Calc. Clapeyron equation.

**Table VI—Vapor-Liquid Composition of Vinyl Acetate-Acetic Acid Mixtures**

| B. P. ° C. Mixture | Per Cent by wgt. V. A. in Liquid | Per Cent by wgt. V. A. in Vapor |
|---|---|---|
| 73 | 100 | 100 |
| 75 | 91.4 | 97.5 |
| 80 | 70 | 90.3 |
| 90 | 40.8 | 73 |
| 100 | 21.5 | 50 |
| 110 | 5.6 | 17.7 |
| 115 | 1.7 | 6.0 |
| 118 | 0 | 0 |

**Table VII—Vapor-Liquid Composition of Acetaldehyde-Vinyl Acetate Mixtures**

| B. P. ° C. Mixture | Per Cent by wgt. AcH Liquid Phase | Per Cent by wgt. AcH Vapor Phase |
|---|---|---|
| 20.8 | 100 | 100 |
| 24.5 | 82.2 | 96.3 |
| 32 | 54.4 | 87.2 |
| 39.5 | 33.9 | 76 |
| 49 | 18.0 | 57.5 |
| 62.6 | 5.3 | 22.4 |
| 73 | 0 | 0 |

**Table VIII—Specific Gravity $\frac{t\ ° C.}{20}$ Data***

| Temp ° C. | Vinyl Acetate | Ethylidene Diacetate |
|---|---|---|
| 0 | 0.9568 | ..... |
| 5 | 0.9510 | 1.0896 |
| 10 | 0.9455 | 1.0846 |
| 15 | 0.9398 | 1.0795 |
| 20 | 0.9342 | 1.0744 |
| 25 | 0.9287 | 1.0693 |
| 30 | ..... | 1.0642 |
| 35 | ..... | 1.0592 |

* Data from the laboratories of the Shawinigan Chemicals, Ltd.

## Properties of Vinyl Acetate

Vinyl acetate is a mobile, colorless, inflammable, nontoxic liquid with an etherial odor and a pungency reminiscent of acetaldehyde. Its vapors have a somewhat irritating effect on the eyes and cause excessive formation of tears. It shows the characteristic behavior of an unsaturated ester; chlorine and bromine form addition products with utmost ease, while addition of iodine is considerably slower.

Hydrolysis of vinyl acetate in water with mineral acids, salts, or alkali is but slightly faster than that of ethyl acetate; the resulting products are interesting in that acetaldehyde and acetic acid are formed, the former owing to the instability of its enolic form, vinyl alcohol. The ester is thermally stable, showing no decomposition up to over 400 deg. C.

Its most characteristic and useful property is the ease with which it condenses to form resinous bodies of high molecular weight. This reaction takes place under the influence of light or heat and is greatly accelerated by peroxide catalysts. These substances are polyesters and the condensation may be controlled to give bodies of any desired complexity. The resins which are free from colors are finding commercial application under the trade name "Gelva."

Ethylidene diacetate is a colorless, flammable, nontoxic liquid with a characteristic but not unpleasant heavy odor. This ester, which is somewhat more readily hydrolyzed than vinyl acetate, also gives acetaldehyde and acetic acid. It is analyzed by saponification, and moderate temperatures and free escape of the liberated aldehyde are recommended. The thermal instability is its most characteristic and useful property. In the presence of catalysts, the decomposition is rapid above 150 deg. C., acetic anhydride and acetaldehyde with some vinyl acetate and acetic acid being the chief products. Ethylidene diacetate has been found useful as an acetylating agent, but its chief importance is in the production of acetic anhydride.

Shawinigan Falls, with the falls and the power house in the foreground

# Montreal and Shawinigan Falls Visited by Electrochemists

EDITORIAL STAFF REPORT

WITH David A. Pritchard heading an active local committee which included among others, T. W. Smith, C. Hazen, J. W. Bain, and J. B. Bell, the success of the Montreal convention of the Electrochemical Society was assured. The program was so crowded with technical sessions, exhibits, excursions, and social affairs that it became well-nigh impossible to attend all of them. The opening scientific session on the morning of May 11 was devoted to aqueous electrolytes. Dr. D. McIntosh of Shawinigan Chemicals, Ltd., presided.

Edgar A. Ashcroft of South Devonshire, England, submitted a detailed account of his leaching researches on Rhodesian copper ores. The ore is given a sweet roast to form $CuSO_4$, this is converted to cement copper and this in turn leached with a chloride solution. A very pure copper is obtained. Commenting on this process Prof. Alfred Stansfield of McGill University felt that any gold in the ore would be lost since it is insoluble in the first leach. C. W. Eichrodt of Nichols Copper Co. referred at length to his own leaching experience extending over many years. It seemed to him that Ashcroft's process was well worth trying out on a much larger scale.

Prof. Colin G. Fink and C. Y. Wong of Columbia University had tackled the problem of finding a copper plating bath for steel which would be more stable and less poisonous than the present cyanide bath. They found that a bath containing disodium diaquodiaxalatocupriate gave good adherent deposits of copper on steel which could be followed by the acid sulphate bath without detriment to the deposit. M. deK. Thompson, G. Soderberg, and R. R. Rogers discussed the paper.

A number of new organic addition agents for cadmium plating have been investigated by R. A. Claussen and H. L. Olin of the State University of Iowa. Cadmium plating has been rapidly finding world-wide recognition. This is doubtless an important niche in the electroplating industry for cadmium. With the proper addition agent, higher current densities may be employed, and at the same time the throwing power is improved. Casein, Bindex and Gulac were used as standards of comparison. Among the new addition agents investigated were Steffen's waste (byproduct of the sugar industry) and the

concentrated steep water produced in the initial soaking of corn in starch manufacture. Steffen's waste compares favorably with Gulac and gives a higher throwing power than the latter. Current densities must be 3.5 to 5.0 amp. per dm.$^2$ for best results. Steep water also gave a better throwing power than Gulac. Casein and Bindex have a narrower current density range than either Gulac, Steffen's waste or steep water.

In discussing the Claussen-Olin paper, Victor L. Soderberg of the General Chromium Corp., Detroit, emphasized the importance of discovering the fundamental principles involved in the behavior of addition agents. Lawrence Addicks referred to the early days of copper refining and nickel plating and how Dr. Edward Weston had accidentally discovered the advantage of glue additions. Prof. O. Maass of McGill University alluded to the close relationship of the addition agent phenomena and those of flotation. U. C. Tainton of Baltimore reported that in zinc winning the use of glue and other organic reagents had been replaced by silicic acid. Leon Westbrook of the Grasselli Chemical Division of E. I. du Pont de Nemours & Co., Cleveland, listed a dozen different reagents tried out in the cadmium bath emphasizing the minute requirements for good results.

In depositing an alloy of cadmium, zinc and antimony Prof. Lawrence E. Stout and his student, L. Goldstein, Washington University, resorted to the cyanide bath. The composition of the deposit is determined by the analysis of the bath, the current density and the temperature. The higher the cadmium content the more resistant to corrosion will be the deposit. M. G. Whitfield of Columbia University referred briefly to the better corrosion-resistant properties of "hot dip" alloys as against electroplated alloys.

Prof. A. Kenneth Graham of the University of Pennsylvania submitted details of his new anode for zinc cyanide baths. It contains 0.5 per cent Al and 0.3 per cent Hg (balance Zn). It operated satisfactorily for many hours without producing any sludge, whereas pure Zn anodes have too high an anode efficiency and produce considerable sludge.

For nickel plating zinc parts Albert Hirsch of Philadelphia recommended first roughening the zinc surface, then copper plating and ball burnishing the copper, and finally nickel plating and ball burnishing the nickel. Chas. H. Eldridge, General Chromium Corp., Detroit, added that it was easier to throw nickel directly on copper than on zinc. But E. A. Anderson of New Jersey Zinc Co. was strongly in favor of omitting the copper undercoat, for the corrosion resistance is better.

### Chromium Plating

In their studies of chromium plating of zinc Professor Thompson and F. C. Jelen of Massachusetts Institute of Technology found that an undercoat of a composite deposit of copper and nickel is two to three times as efficient as nickel alone of the same thickness as that of the composite deposit.

As previously reported, mere traces of germanium seriously interfere with the deposition of zinc from the sulphate bath. Harold Lundin of the Tainton Research Laboratories worked out an analytical method for its detection and estimation. Tainton pointed out that little use for germanium has as yet been found. Comparatively large quantities of the element can be made available from flue dust, at least a ton a month. Another rare element byproduct of the zinc industry is indium, as previously reported by the Grasselli Chemical Co. A. W. Downes and Prof. L. Kahlenberg of the University of Wisconsin investigated the properties of the Grasselli product. Indium, like tin, makes alloys harder and stronger.

Arthur B. Purvis, president and general manager of the Canadian Industries, Ltd., formally greeted the members and guests from all parts of Canada, the United States, and Europe at the luncheon on Thursday. In his address Purvis emphasized the international character of the electrochemical industry and the importance of the international scope of the society, by saying, "Your society as an international body must be a nucleus for the further development of those ideals of international good will and well-being."

### Flotation

Professor Maass then opened the round table discussion on flotation. John W. Bell, C. G. Schluederberg, Tainton, Fink, and others participated in the debate. The flotation of gold ores, low-grade non-metallics, coal, and others were briefly touched upon.

Professor Thompson opened the second technical session with his paper on the seat of the electromotive force in voltaic cells. On the basis of his studies Thompson concludes that the potential between two metals connected metallically in a vacuum or in a gas has nothing to do with the potential of the same metals when combined to form a voltaic cell.

Prof. W. O. Reevely and Prof. A. R. Gordon of the University of Toronto described a simple micro-coulometer with which the transport numbers for potassium were determined using the moving boundary method. Results were reproducible and reliable. D. F. Calhane and C. M. Alber of Worcester Polytechnic Institute recommended the use of tantalum cathodes in place of the more costly platinum ones. Fink and G. C. Lambros experimented with various rhodium plating baths and found the ammonium sulphate bath to give most satisfactory results. The large searchlight reflectors of the transcontinental airways are all rhodium plated. A. H. Taylor of Nela Park, Cleveland, submitted latest values on reflectivity from plated surfaces: silver, 90 per cent; rhodium, 66 to 78; chromium, 62 to 66, and nickel, 60 to 63.

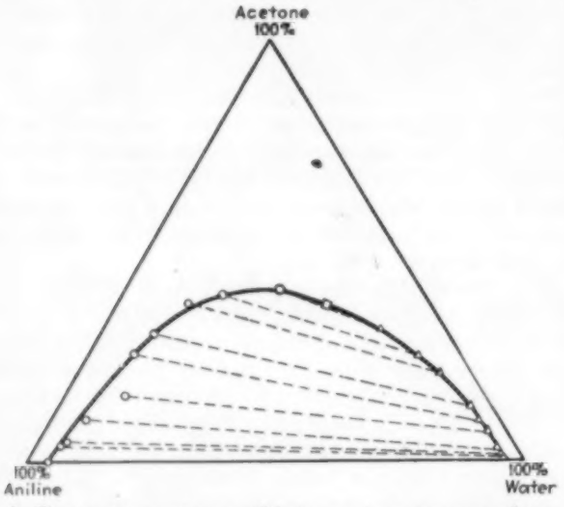
A particularly interesting paper was that of Ernest A. LeSueur, pioneer in electrolytic alkali cells. L. D. Vorce, a consultant; Arthur E. Gibbs of Pennsylvania Salt Co., and Ralph M. Hunter of Dow Chemical Co. participated in the discussion referring to the early competition of the Le Blanc and ammonia soda processes. It was LeSueur who first conceived the idea of maintaining a pressure on the anolyte of the diaphragm cell.

W. S. Kirkpatrick, B. P. Sutherland and C. H. Wright of Trail, B. C., described the large commercial electrolytic hydrogen and oxygen installation of the Consolidated Mining & Smelting Co. At 60 deg. C. the optimum concentration is 29 per cent KOH. With a 24 per cent solution and Ni-plated anodes an efficiency of 138 kw.-hr. per 1,000 cu.ft. of gas was obtained.

Frank W. Godsey, Jr., of New Haven, stated that the

formation of electrolytic condensers in aqueous electrolytes has formerly been assumed to be approximately inversely proportional to the voltage of formation in relation to the resultant capacity of the anode. However, on the basis of his own carefully conducted measurements this assumption appears to be greatly in error at the lower formation voltages, both for alternating and direct current formation, the measured capacities being much less than formerly assumed.

R. D. Blue and F. C. Mathers of the University of Indiana found that although pure aluminum could not be deposited from a solution of aluminum chloride in formamide, alloys of aluminum with iron, and with zinc could be deposited. The quantity of aluminum reached 17.65 per cent in the alloy with iron. Sherlock Swann, Jr., of the University of Illinois, showed that iron salts inhibit the reduction of bensophenone to benzpinacone at aluminum cathodes in aqueous-alcoholic surphuric acid solution. Alan Newton Campbell and Edith M. Brown of the University of Manitoba studied the system aniline-acetone-water and obtained the value $Kb = 2 \times 10^{-10}$ for the true basicity or affinity constant of aniline.




**Aniline-acetone-water equilibrium. △ = aqueous phase, ○ = aniline phase, □ = critical composition**

D. F. Calhane and C. C. Wilson of the Worcester Polytechnic Institute found that the four factors that influence electrolytic production of nitronaphthalene are time, strength of acid, strength of current, and temperature of the electrolyte.

The Friday morning session was opened by Pres. R. A. Witherspoon. In his address he referred to the almost unlimited resources of the Shawinigan district and the attractive electric power rates. Shawinigan has grown into one of the foremost electrochemical centers of America.

Professor Stansfield presided and opened the discussion on electric furnaces and their products with a brief survey of the Canadian electric furnace industry. The value of the annual output of electric furnace products in Canada exceeds $35,000,000. Aluminum and carbide head the list, other products include abrasives, ferro alloys, electric steel, electrodes, and graphite.

The Norton Co. submitted two splendid papers: the first by Bruce L. Bailey and Raymond R. Ridgway on the determination of maximum current-carrying capacity of furnace electrodes, and the second by Ridgway, A. H. Ballard, and Bailey on hardness values for electrochemical products. The latter paper covers a thorough study of "hardness" and will be welcomed by many chemists and engineers. The following table is of particular interest:

**Impact Abrasion Hardness Numbers**
**No. 30 E-1 Alundum Abrasive Blast**

| Sample No. | Sample | Relative Figures |
|---|---|---|
| 15a | Tungsten carbide alloy | 600 |
| 15a | Tungsten carbide alloy | 600 |
| 15b | Tungsten carbide alloy | 300 |
| 11 | Boron carbide | 182 |
| 13a | Stellite | 150 |
| 14 | Tantalum carbide alloy | 71 |
| 10a | Silicon carbide | 53 |
| 9a | Fused alumina | 18 |
| 9b | Fused alumina | 17 |
| 8 | Fused zirconia | 15 |
| 5 | Quartz | 3.0 |
| 6 | Topaz | 2.8 |
| 2 | Fused magnesia | 2.3 |
| 3 | Fused silica | 1.9 |
| 16 | Mullite | 1.9 |
| 17 | Plate glass | 1.0 |
| 4 | Beta alumina | 0.3 |

G. S. Diamond of the Electro Refractories and Alloys Corp. described a new silicon carbide refractory brick for electric furnaces. This brick, Tercod, is inert to acid or neutral slags and is applicable to melting irons with 3 per cent C and to low-carbon steels and nickel.

C. H. Von Baur has spent two years in Russia. He reports that by the end of 1934, 449 electric furnaces, mostly Heroults, will be in operation.

Of special interest was the paper presented by George O. Morrison (jointly with T. P. G. Shaw) on byproducts of the carbide industry: the manufacture of ethylidene diacetate and vinyl acetate. (It appears on pages 293-297 of this issue of *Chem. & Met.*)

A. Dingwall, J. Zacharias, and S. L. Siegel of Columbia University described an interesting case of the contamination of pure nickel by molybdenum upon melting the nickel in a molybdenum resistor furnace.

The electrolytic plant of the Canadian International Paper Co. at Temiskaming was described by its chemical engineer, John Hedalen. Two hundred and forty Nelson cells are used; hypochlorite of lime, hypochlorite of soda, and caustic soda are made. The cells operate at 53 per cent energy efficiency. The caustic pots are electrically heated; 1,410 kw.-hr. are consumed per ton of caustic fused.

Saturday was devoted to a visit of the industries at Shawinigan Falls. From the power house the party proceeded to the plant of the Aluminum company to see the new improved Hall cell in operation. At the Carbide company's plant the new furnace was about completed. The three Soderberg electrodes are 5 ft. 2 in. in diameter, 60,000 amp. per electrode. Then the Canadian Chemicals plant with its many acetylene derivatives and its new process for the recirculation of the lime was visited. And, finally, the party visited the paper mill.

At the banquet President Witherspoon announced the awards of the society. The Edward Goodrich Acheson Medal was awarded to Prof. Colin G. Fink and will be presented at the fall meeting of the society. This award is made once every two years to the "person who shall have made such contribution to the advancement of any of the objects, purposes, or activities of the society." The Weston fellowship for 1933-1934 was presented to R. D. Blue of Indiana University. And the prize to young authors for the best paper during 1932 went to Frank W. Godsey, Jr., of New Haven.

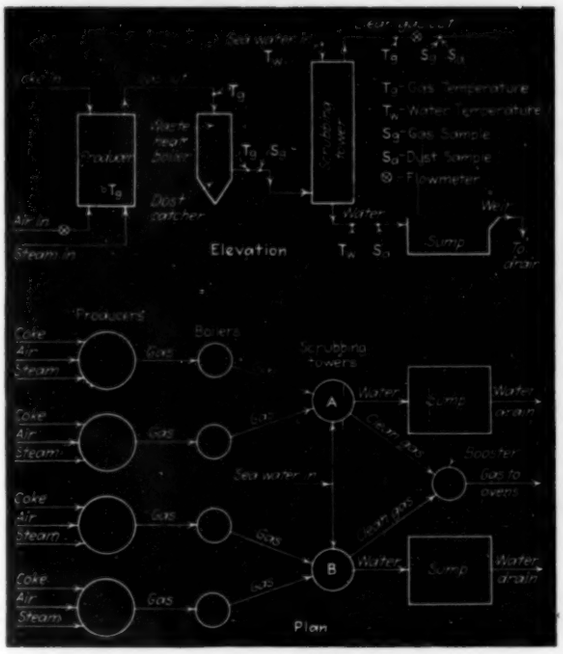



**Fig. 1—Layout of producer plant**

# Design of Grid-Packed Cooling Towers

By C. C. FURNAS

AND

R. H. NEWTON

*Department of Chemical Engineering*
*Yale University*
*New Haven, Conn.*

HEAT TRANSFER coefficients for the design of grid-packed scrubber towers for a saturated gas, as in oil and water-gas plants, has been given by Rosebaugh (*Chem. & Met.*, Mar., 1928, p. 144-8). Similar data for the design of towers for substantially dry gas at high temperatures, as that from producers, have not been available and this paper attempts to fill this need.

The data on which this paper is based were obtained in a 72-hour test at the producer plant of the Connecticut Coke Co., New Haven, Conn. Gas from four coke-fired producers, blown with steam and air, passes through four waste-heat boilers, and thence to two scrubbing towers of the combined spray and grid-packed type. The hurdle packing begins 2 ft. below the spray heads, which are fed with sea water. There are six spray heads at the top of each tower. The hurdles are set in pairs (15 pairs to a tower) with approximately 2 ft. clearance between each set. Each hurdle is made up of 20 slats, $\frac{3}{4}$ in. x 6 in. with $3\frac{3}{4}$ in. clearance between slats. The hurdles in each pair are set at right angles to each other. The towers are 60 ft. high and 8 ft. in diameter. The active volume of each tower is about 2,500 cu.ft., and the total slat surface about 5,000 sq.ft. A diagrammatic sketch of the plant lay-out is given in Fig. 1.

In normal operation three of the four producers are used and send up to 1,000,000 cu.ft. of gas per hour through the towers. During the test the rates of gas flow varied from 0.084 lb. per sq.ft. of cross-sectional area of tower per second to 0.231 lb./sq.ft./sec. The water flow varied from 0.188 lb./sq.ft./sec. to 0.714 lb./sq.ft./sec. The ratio pounds of gas to pounds of water varied from 0.143 to 0.800. The temperature of the entrance gas averaged 565 deg. F. and the gas leaving the tower averaged 74 deg. F. The incoming water averaged 66 deg. F., the outgoing, 112 deg. F.

The gas was essentially dry, since the coke used contained only 4 per cent moisture, corresponding to only 1 per cent water vapor in the gas. The average gas composition in percentages was: $CO_2$, 5.0; $O_2$, 1.0; CO, 26.9; $H_2$, 9.3; $N_2$, 57.2; and $CH_4$, 0.6 per cent. The average heat capacity of this gas at the average temperature was computed to be 0.29 B.t.u./lb./deg. F. The measured heat capacity, as determined by the heat balance of the waste-heat boilers, was 0.31 B.t.u./lb./deg. F. The average figure 0.30 B.t.u./lb./deg. F. was used in making the design computations which follow.

### Coefficients in Waste-Heat Boilers

The measured overall coefficients of heat transfer between the gases and the boiling water in the waste-heat boilers are as follows:

| Gas Velocity Through Tubes, Lb./Sec./Sq.Ft. | Coefficient *H*, B.t.u./Hr./Sq.Ft./Deg. F. |
|---|---|
| 0.855 | 6.3 |
| 0.852 | 6.2 |
| 0.730 | 5.1 |
| 0.719 | 5.3 |

The boiler tubes were 3.67 in. I.D. and 20 ft. long.

### Elimination of Dust

The towers not only act as coolers, but also as dust scrubbers. Dust samples were taken from the gas stream leaving the scrubbing towers. The average dust content of the gas was 6.0 grains per 1,000 cu.ft. The dust content showed no significant variation with changes either in water flow or gas flow over the range studied. This datum shows that the dust going into the mains after the towers is about 20 lb. per day.

Data were taken on the amount of dust contained in the water after it has passed through the scrubbers. The data were quite erratic. The average dust content was 0.0004 lb. of dust per lb. of water. This represents a dust elimination of approximately 2,000 lb. per day in the

towers. The scrubbing towers remove approximately 99 per cent of the dust from the gas.

### Heat Transfer in the Tower

The actual mechanism of cooling of the gas in the tower is too complex to be exactly treated in any simple manner. As the dry, hot gas enters the bottom of the tower its temperature history tends to follow the adiabatic cooling curve, if its velocity is sufficiently high. At some unknown distance up the tower it becomes a saturated gas at some temperature considerably below the entrance temperature. As it proceeds up the tower from this point, it is a saturated gas which is being cooled and dehumidified by the countercurrent stream of water. Unless temperatures and degrees of saturation are known at intermediate points it is not possible to give a complete analysis of the exact conditions. The case for the temperature history of a saturated gas which is being cooled and dehumidified is treated by Mason (Proc. A.G.A., pp. 1154-6, 1925), but the case under consideration is more complex and cannot be so treated.

Because of the lack of a better method, the data were treated as if they were those of a dry gas being cooled by a non-volatile liquid. The exit gas was considered as dry gas plus a certain amount of vapor which had entered into the gas stream.

Heat lost by the gas was used as the basis for the determination of the amount of heat transferred. The heat-transfer coefficients were computed on the basis of the logarithmic mean temperature difference between gas and water at the top and bottom of the towers. If the data are applied in the same manner, *i. e.*, using the logarithmic mean temperature difference, they may be counted on to be fairly accurate in the ranges studied and are probably reliable for some extrapolation.

A careful study of the heat transfer data in the tower showed that the coefficient varied as a linear function of the water flow and as the 0.4 power of the mass rate of gas flow. The variations in temperature during the test were not sufficient to detect any effect of temperature change of the entering gas.

The data obtained are plotted in Fig. 2 as the heat-transfer coefficient against rate of water flow. The data have all been corrected to a gas flow of 0.192 lb./sec./sq.ft. (equivalent to 10,000 cu.ft./hr./sq.ft.). The equation of this line which best interprets the data is

$$H_v = 21\ W + 14.0\ G^{0.4} \qquad (1)$$

where $H_v$ = B.t.u./hr./cu.ft./deg. F., $W$ = lb. water/sec./sq.ft., and $G$ = lb. gas/sec./sq.ft.

The coefficient of heat transfer per unit of area, $H_a$, is equal to $\frac{1}{2}$ the value of $H_v$, for the slat surface in the tower is about 2 sq.ft. per cu.ft. A plot of equation (1) is given in Fig. 3, for several values of $G$.

### Design of Towers

*Fundamental Relations*—As mentioned above, the data for heat transfer in the towers were computed on the basis of the logarithmic mean temperature difference where

$$\Delta T_m = \frac{\Delta T_1 - \Delta T_2}{\ln_e \frac{\Delta T_1}{\Delta T_2}} \qquad (2)$$

where $\Delta T_1$ is the temperature difference between gas and water at the bottom of the tower and $\Delta T_2$ is the temperature difference between gas and water at the top of the tower.

In order to design a tower it is necessary to know the exit and entrance temperature of both gas and water. If the desired entrance and exit temperatures of the gas are assumed, as well as the entrance temperature of the water, the exit temperature of the water is determinable. If the gas carried the same amount of moisture when it left the tower as when it entered, all the sensible heat of the gas would be transmitted directly as sensible heat to the water, the heat transfer being represented by the equation

$$\Delta T_g\ GC_g = \Delta T_w\ WC_w$$

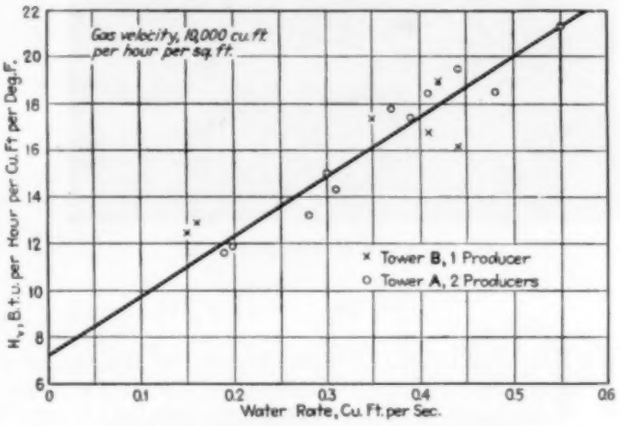
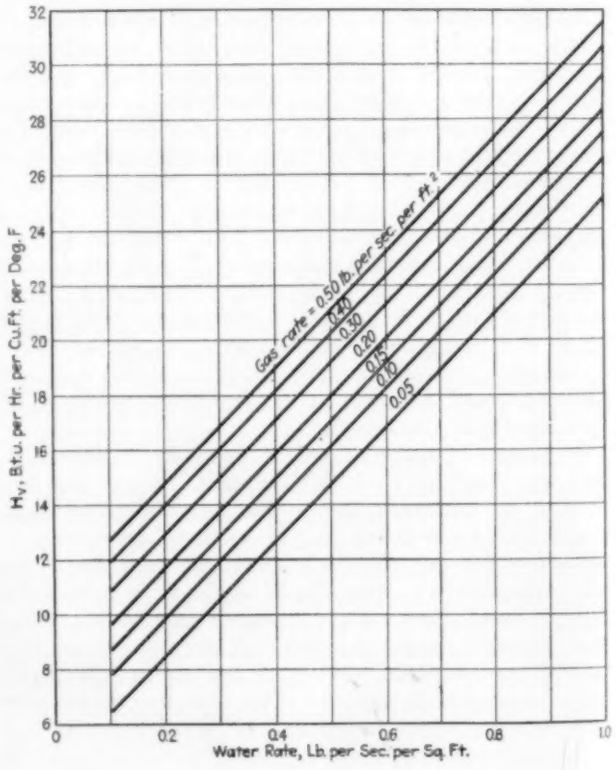

Gas velocity, 10,000 cu.ft. per hour per sq. ft.
× Tower B, 1 Producer
○ Tower A, 2 Producers
$H_v$, B.t.u. per Hour per Cu.Ft per Deg.F.
Water Rate, Cu. Ft. per Sec.

**Fig. 2—Relation between heat transfer coefficient and water flow**

**Fig. 3—Relation between heat transfer coefficient, water flow and gas flow**



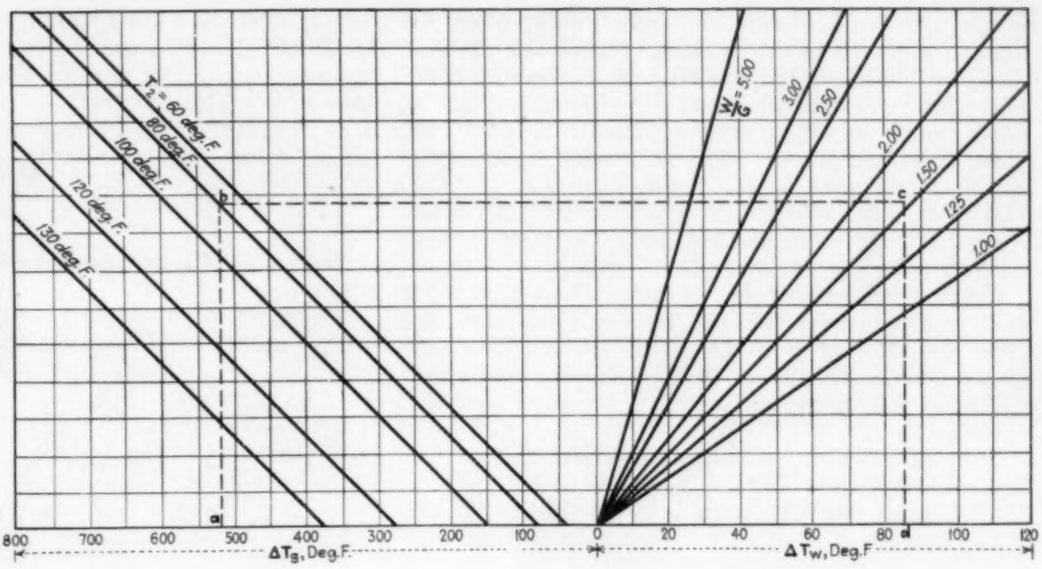
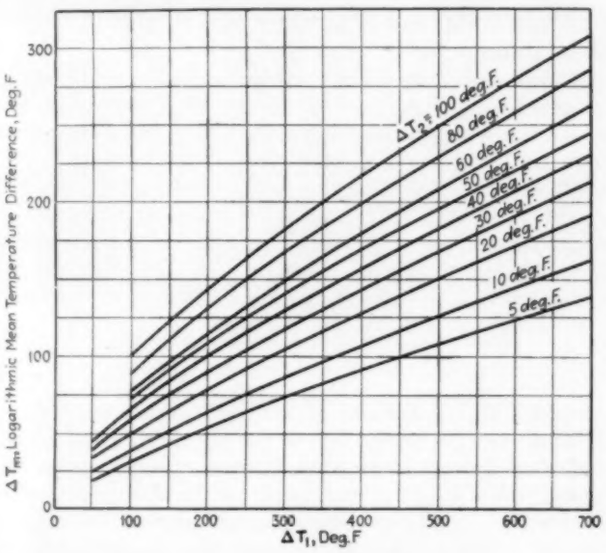



**Fig. 4—Diagram for Determining Relations of Temperature Changes and Flow Rates**

**In the example, where the water temperature increases 85 deg., and the gas temperature decreases 520 deg. to 80 deg. F., the ratio of water rate to gas rate is found to be 1.55**

**Fig. 5—Logarithmic mean temperature difference in cooling towers**


$\Delta T_2$ = 100 deg. F.
80 deg. F.
60 deg. F.
50 deg. F.
40 deg. F.
30 deg. F.
20 deg. F.
10 deg. F.
5 deg. F.
$\Delta T_m$ Logarithmic Mean Temperature Difference, Deg. F
0 100 200 300 400 500 600 700
$\Delta T_1$, Deg. F

This equation may be rewritten in the form

$$\Delta T_g = \Delta T_w \frac{WC_w}{GC_g}$$

where $\Delta T_g$ and $\Delta T_w$ are respectively the change in temperature of the gas and the water; $G$ = rate of flow of gas, lb./sq.ft./sec; $W$ = rate of flow of water, lb./sq. ft./sec.; $C_g$ = heat capacity of the gas, B.t.u./lb./deg. F.; and $C_w$ = heat capacity of the water, B.t.u./lb./deg. F.

### Heat for Vaporization

However, this condition does not hold, for, in the case being considered, the gas enters practically dry and leaves the tower saturated at some temperature above that of the entrance water. Then, instead of all of the sensible heat of the gas going into sensible heat in the water, part of it goes into heat of vaporization of sufficient water to saturate the gas leaving the tower. This condition is represented by the equation

$$\Delta T_g GC_g - Q_T V_T G = \Delta T_w WC_w \qquad (3)$$

where $V_T$ is the pounds of water vapor in saturated gas at the exit temperature of the gas, and $Q_T$ is the latent heat of vaporization of the water at the given temperature.

$Q_T$ and $V_T$ are both functions of the exit temperature of the gas, $T_2$, and so should be expressible in terms of $T_2$. Hence, for a gas of a given heat capacity, the ratio of $\Delta T_g$ to $\Delta T_w$ is determined by the exit temperature of the gas, $T_2$, and by the ratio, $W/G$.

For convenience in computation, the relation between $\Delta T_g$ and $\Delta T_w$ for various values of $T_2$ and $W/G$ is given in the double graph of Fig. 4, for a gas with a heat capacity of 0.30 B.t.u./lb./deg. F. As a further convenience, the logarithmic mean temperature differences for various values of $\Delta T_1$ and $\Delta T_2$ are plotted in Fig. 5.

In tower design, the values obtained from these figures are to be used in the equation

$$\Delta T_g GC_g = h_v L \Delta T_m \qquad (4)$$

where $h_v$ = B.t.u./cu.ft./deg. F./sec., L is the tower height in feet and $\Delta T_m$ is the logarithmic mean temperature drop.

### Tower Design Examples

*Example*—Assume that 200,000 cu.ft. of gas per hour of specific gravity 0.07 and specific heat 0.30 is to be cooled from 600 deg. F. to 80 deg. F. in a tower of the type described above, with water entering at 65 deg. F. What is the minimum diameter and height of tower and the minimum water rate which will handle this amount of cooling?

*Solution, Limiting Conditions*—The operation of the towers described above indicated that it is not feasible to operate with exit water temperatures greater than 150 deg. F., for above this temperature, the formation of steam in the bottom of the tower seriously interferes with the cooling function. This exit-water temperature fixes the minimum water rate. In the problem $\Delta T_g$ = 520 deg. F. and gas flow = (200,000/3,600) × 0.07 = 3.89 lb. per sec. Furthermore, the maximum permissible $\Delta T_w$ = 150 — 65 = 85 deg. F. The ratio of water flow

to gas flow can be determined from Fig. 4, where the solution is shown in dotted lines. Follow line *ab* from $\Delta T_g = 520$ to the intersection with the line $T_2 = 80$, follow line *bc* horizontally to the right to intersect line *cd*, which rises vertically from the value of $\Delta T_w = 85$. These two lines intersect at point *c*, which, by interpolation, is found to be on the diagonal for $W/G = 1.55$. Therefore, water flow $= 1.55 \times 3.89 = 6.03$ lb. per sec. Note that Fig. 4 can be used for either total gas and water flow, or for flow per unit of area.

It is generally considered in tower design that water flows greater than 0.8 lb./sq.ft./sec. cause flooding of the tower and blocking of the gas flow. However, with the spaced-grid construction of the type of tower under consideration this figure can safely be increased to 1 lb./sq.ft./sec.

Then the cross-sectional area of the tower $= 6.03/1 = 6.03$ sq.ft. and $D = 2.77$ ft. Gas flow $= 3.89/6.03 = 0.645$ lb./sq.ft./sec. This rate is larger than any shown in Fig. 3 so the value of $H_v$ will be computed from equation (1). In this equation $H_v = 21 \times 1 + 14.0 \times (0.645)^{0.4} = 32.7$ B.t.u./hr./sq.ft./deg. F. At the bottom of the tower $\Delta T_1 = 600 - 150 = 450$ deg. F.; at the top of the tower $\Delta T_2 = 80 - 65 = 15$ deg. F. From Fig. 5, $\Delta T_m = 128$ deg. F. From equation (4)

$$L = \frac{520 \times 0.645 \times 0.3 \times 3{,}600}{32.7 \times 128} = 86.5 \text{ ft.}$$

This gives as the solution a diameter of 2.77 ft. and a height of 86.5 ft.

*Practical Solution*—Such a tower, 2.77 ft. in diameter and 86.5 ft. high, which represents the minimum diameter, is decidedly out of proportion for construction purposes. It is much more feasible to use a tower of greater diameter. Hence, assume a tower 5 ft. in diameter with the same total water and gas flows, and same exit temperatures. Then $G = 0.21$ lb./sq.ft./sec. and $W = 0.325$ lb./sq.ft./sec. From Fig. 3, $H_v = 14.3$. From equation (4)

$$L = \frac{520 \times 0.21 \times 0.325 \times 3{,}600}{14.3 \times 128} = 70 \text{ ft.}$$

In this case the tower called for has a diameter of 5 ft. and a height of 70 ft.

*Increasing Water Flow*—If water flow were increased to 0.5 lb./sq.ft./sec., leaving the gas exit temperature at 80 deg. F., a shorter tower would suffice. For this case $W/G = 2.4$. From Fig. 4, with $\Delta T_g = 520$ deg. F., $T_2 = 80$ and $W/G = 2.4$, $\Delta T_w = 55$. Therefore, exit water temperature $= 65 + 55 = 120$ deg. F., $\Delta T_1 = 480$ deg. F., and $\Delta T_2 = 15$. From Fig. 5, $\Delta T_m = 134$ deg. F. From Fig. 3, $H_v = 18$. From equation (4)

$$L = \frac{520 \times 0.21 \times 0.325 \times 3{,}600}{18 \times 134} = 53 \text{ ft.}$$

Hence, in this case a diameter of 5 ft. and a height of 53 ft. suffice.

*Acknowledgment*—The authors wish to acknowledge the generous aid and cooperation of W. C. Wardner and B. R. Hasselman and other officials of the Connecticut Coke Co., who made it possible to obtain the data presented above. We also wish to acknowledge the services of Profs. B. F. Dodge and M. C. Molstad and of the following students of Yale University: H. H. Bassford, C. C. Donovan, W. L. Elwood, J. R. Erickson, R. B. Korsemeyer, J. L. Marsh, H. W. Peyser, A. Sinnickson, J. F. Thornton and W. H. Wetherill.

# Rhodes Marsh Yields Its Sodium Sulphate

By P. C. RICH

*Chemical Engineer*
*Rhodes Alkali & Chemical Corp.*
*Mineral County, Nev.*

WITH THE COMPLETION, late in 1932, of the new plant of the Rhodes Alkali & Chemical Corp., the United States has moved one step nearer to complete independence of foreign salt cake. As a result of the domestic shortage and increasing importations of the product following changes in the manufacture of nitric and muriatic acids, interest was revived a number of years ago in the various deposits of natural glaubers salt and brines that are found in a number of isolated desert regions in the West. As a result, natural sulphate production rose to 32,630 tons in 1930, as compared with 7,540 tons in 1929. For the next two years production remained about the same, falling to 32,204 tons in 1932. Of this, most of the salt cake was produced by two concerns, Rhodes and the Arizona Chemical Co., at Camp Verde, Ariz.

Rhodes Marsh, the site of our new plant, 9 miles south of Mina, Nev., is on the line of the Southern Pacific Railroad that serves Tonopah. Present freight rates, although out of line compared with those of other commodities, make possible competition with imported material in the Pacific Northwest. An equitable adjustment of rates will open up new markets in the paper mills of the Gulf region.

Exploitation of the marsh began in the days of Virginia City and the gold and silver strike on the Comstock Lode, when salt was mined for use in the extraction of silver. The several mining claims covering the mineralized area were consolidated into the Rhodes Salt & Borax Co. which produced borax until "Borax" Smith began the operation of the large deposit in Death Valley. The deposit then passed into the hands of the Betty family, of Mina, and small amounts of salt were produced until 1911.

A few years ago P. S. Williams, a chemical engineer at one time associated with a concern producing sodium sulphate from Carrizo Lake, Calif., came across an old report of Prof. Joseph Le Conte, geology professor at the University of California, in which mention was made of an enormous deposit of glaubers salt at Rhodes. In 1928 he was able to interest a group of San Francisco men who spent considerable time prospecting the deposit, surveying the markets, and investigating processes for recovery of the sulphate. The first plant was erected in 1930. With the experience thus gained

**Rhodes Valley, looking east from plant**
**Loading crude thenardite after stripping**
**Plant of Rhodes Alkali & Chemical Corp.**

as a basis, a program of improvement was initiated late in 1932, under the superintendence of D. E. Root. At the present writing the production is about 50 tons of finished salt cake per day.

Rhodes Marsh is roughly circular in shape. The mineralized section is about 200 acres in area and covered with 6 in. to 2 ft. of silt. On the south half of the deposit, a 15-ft. layer of glaubers salt is found immediately under the overburden; in places it has been found to be present at a depth of 80 ft. This portion of the marsh is fed by small springs, and a well drilled south of the deposit has developed an artesian flow of several hundred gallons per minute. The north half of the deposit is slightly different in character, large areas having been marked in which the glaubers salt is overlain with thenardite (anhydrous sodium sulphate) in a layer from 3 to 5 ft. thick. In this portion the overburden consists of salt (NaCl) as well as fine silt.

Initial efforts to develop a process for the production of salt cake were directed toward the utilization of the seasonal temperature changes, using the natural brines, or brines made by passing water over or through the glaubers beds, as the starting point. Next, an attempt was made to free the glaubers salts from the silt mixed with it during mining as a solid, and then to dehydrate with heat or precipitate with salt. The present process, which is much simpler, consists in mining and purifying the beds of thenardite. The extent of the latter was not realized until comparatively recently.

Operations as at present conducted fall into two classes, mining and plant. In mining, the overburden, consisting of salt and silt, is stripped with a gasoline shovel which works well ahead of the actual mining to provide time for the lowering of the brine level in the deposit by means of two portable pumps. The thenardite layer, 3 to 5 ft. thick, is formed of crystals so well consolidated that drilling and blasting is necessary. A gasoline-driven shovel equipped with a trench hoe attachment loads the lumps into 2-yard dump cars operating on a 36-in. track, which can be moved, if necessary, to avoid rehandling of the ore. Four to six cars are then hauled about a mile to the plant, where a stock pile is maintained to provide for continuous processing should the field operations be interrupted.

In the plant, treatment is merely a process for the removal of salt and silt. This is done so as to maintain as far as possible a counter flow of materials and liquors and to utilize the nearly saturated solutions whenever possible so as to prevent losses. From an elevated platform, where the ore is dumped, it is fed to a jaw crusher from which it travels to a washer. The latter is a long trough equipped with paddles and serves to separate the individual crystals from the silt, while at the same time it assists in the solution of the NaCl. The muddy overflow from the washer goes to waste.

Solids from the washer are elevated to a dewatering screen and then delivered into a duplex Dorr classifier. Solution from the screen flows back into the washer. As the solids work up the deck of the classifier they are sprayed with warm water as a final wash and the overflow liquors from the classifier are pumped into the washer. Both the washer and the classifier are kept warm to avoid formation of glaubers salt, which would later cause trouble by caking in the dryer.

Drained material from the classifier is then fed to a 40-ft. rotary dryer, heated with oil and supplied with air, from a dust removal system at the discharge end. The dried product passes through rolls, for reduction to minus 3 mesh, and is then elevated to flow by gravity to the stockpile, or direct into the cars in which it is shipped.

Power is furnished to the plant by a diesel engine, which drives all the machinery through belts. Wells furnish an ample supply of the water used without treatment in the small boiler. One 8-hour shift will produce over 50 tons of finished product per day. The normal product, as shown by a typical analysis, contains 97.33 per cent of $Na_2SO_4$, with the remainder including NaCl, 1.07; $CaSO_4$, 0.28; insoluble, 1.24; and moisture, 0.08 per cent. By screening out and grinding the coarser material from the dryer, the impurities may be further reduced, if necessary, to furnish a material well over 98 per cent sodium sulphate, with less than 0.75 per cent insoluble.

Despite a violent earthquake which centered only 10 miles from Mina late in 1932, and a winter which covered the section with 2 to 3 ft. of snow, production has been maintained. With the coming of hot weather, operations should be expedited, while at the same time the heat is expected to reform thenardite so that the same area can be reworked in 2 or 3 years without additional stripping.

# Simplify Your Process by Combining Drying and Grinding Operations

By LINCOLN T. WORK
*Assistant Professor of Chemical Engineering*
*Columbia University, New York, N. Y.*

THE LAST DECADE has witnessed many developments in the reduction of particle size of materials. In this field, as in many others, what has been considered impossible has on occasion become the simplest method of procedure. That may be illustrated by the recent development of drying and grinding in one operation. For a long time it was considered necessary to feed to a pulverizing machine a thoroughly dried solid. Many plants containing grinding equipment have had included large and expensive dryers in order that the solid to be fed to the mill shall be so dry that there is no tendency for caking during grinding.

Wet grinding was known only as the grinding of a pulp, a fluid mixture of liquid and solid. It was a common statement among men who operated grinding equipment that material to be pulverized must be either very wet or very dry. This did not prevent the development of a combination of drying and grinding in the same machine. As this new method is now operated, moist or plastic material may be fed to the mill; but due to the drying conditions which prevail within the mill the material being ground is really quite dry. Stages in the development of this method are briefly reviewed.

Many years ago the mining industry adopted closed circuit wet grinding in order to avoid the formation of too much very fine material and in order to effect economy in power. In this method the wet mixture flows through the mill, is partially reduced to the required size, and then flows to a separating device. Here material finer than a certain size is washed away as finished, and the oversize is returned to the mill with the feed. More recently the same principle of closed circuit grinding has been applied to the pulverization of dry materials. The mills are swept with air, and the fines as formed are lifted out by the air stream. The coarse grits remain in the mill until reduced to a suitable size. It was but a short step beyond this to employ warm air. This dried the material within the mill and eliminated the preliminary drying of moist materials.

This paper outlines a few of the achievements in this combined unit operation of grinding and drying, and presents an analysis of the factors involved.

This combination of two operations in one machine has been applied to a large number of problems of pulverization. These include the grinding of minerals received in a wet condition, the disintegration of filter cakes directly from the press, and the dehydration and disintegration of crystalline hydrates.

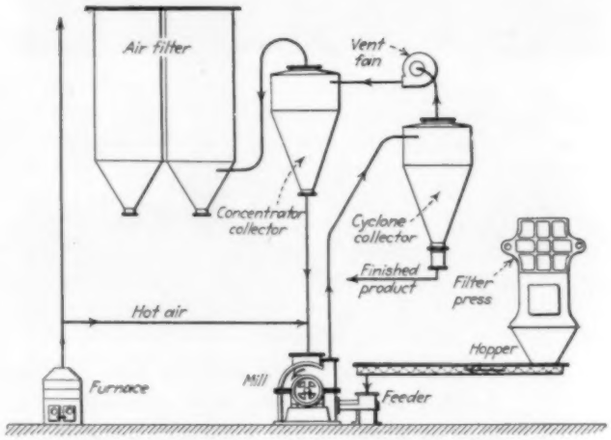



**Fig. 1—Flowsheet of a Raymond kiln-mill installation in a chemical plant for dehydrating and reducing a filter-press product to a fine dry powder in one operation**

The pulverization of coal offers examples of this combination in the mineral field. Before drying and grinding were combined into one operation the coal had to pass through a preliminary dryer in order to eliminate the moisture, and the capacity of this dryer had to accommodate any water content which the coal might have. Since the coal as delivered may range in moisture content up to 18-20 per cent, which is dripping wet, this procedure was cumbersome and costly. With the drying and grinding as one operation it has become possible to feed coal of any moisture content directly to the mill with only limited reduction in power consumption and mill capacity. The warm air which sweeps through the mill dries the coal and carries it directly to the burner or to a separator from which it is stored. In the direct firing the warm air also represents pre-heating; and offers the further advantage of minimum danger from spontaneous combustion and from explosion. The compactness and flexibility which result from drying and grinding in the same machine were especially important

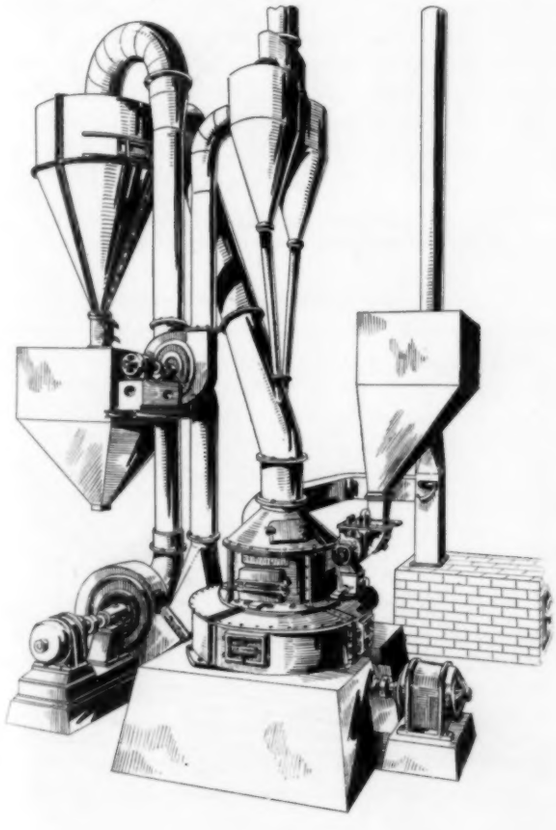
in the adaptation of pulverized coal to marine boilers.

Other mineral materials besides coal may be dried and ground in one operation with highly satisfactory results. These include cement raw mixture, limestone, bauxite, phosphate rock, barytes and talc. A special example of ground minerals is that of gypsum. When pulverized and floated in air maintained at the proper temperature, the powder is dehydrated into plaster of paris. Other crystalline materials besides gypsum have been ground and at the same time reduced from one state of hydration to another. Blue copper sulphate may be converted to a mono-hydrate in a single operation, and the uniform blue-white product which results is useful in the insecticide field.

The application of the combination of drying and grinding has been extended to the field of disintegration. Cake from the filter press is dropped directly into a hopper from which it is fed to the grinding mill (Fig. 1). It is dried and disintegrated, and is removed as a finished powder from the separator. Organic materials which are susceptible to heat have been handled in the same manner. Fruit pulp, containing from 80-85 per cent moisture, is converted into a dry powder. Milk albumen, after processing to about 65 per cent water, is reduced to less than 8 per cent water by a grinding of this type.

The usual types of grinding machines may be used in conjunction with such a dual operation. The cylindrical ball mill, the conical ball mill, and many types of ring roller or ball roller mills, impact mills and beater mills, which are employed in dry grinding may be used. Fig. 2 illustrates a well-known type of roller mill used with an air separating and drying system. The choice of mill is affected by the nature of the material to be reduced and not primarily by its moisture content. The moisture is taken care of by proper control of the temperature of the air which is circulated. A certain amount of air circulates through the mill and separators and back again to the mill. A portion is led away through a dust collector, and the make-up of new warm air is brought into the stream and thoroughly mixed with it before the air enters the mill. In this way the accumulated moisture in the atmosphere is maintained at a sufficiently low value to insure drying. The thorough mixing of the new warm air with the circulating air assures exact and uniform temperature. The hot gases may be hot air from a heater or heat recovery system, or they may be flue gases or other inerts when there is danger from oxidation.

**Fig. 2—Roller type mill with air drying and separation**



### Feeding Moist Solids

The feeding of moist solids to grinding mills which are not swept by air causes caking. The material is pressed together until it forms hard lumps and pulverizing ceases. It is a simple matter to apply a crushing load to a coarse piece of material whether wet or dry. If that load can be applied directly, the piece will be ruptured. Hence the moisture problem is of little concern in coarse grinding mills, and it is only when appreciable quantities of material less than sieve size are produced that there is marked impedance to mill action. As the new surface is produced it becomes wet, probably by a blotting action, as it comes in contact with wet material. The surface moisture causes the particles to cluster into small balls or agglomerates.

At first these agglomerates are plastic; that is, they can flow into other shapes under load, but they offer definite resistance to the forces of grinding. Therefore when the crushing load is applied, they slowly change shape to conform, and the load seldom reaches the coarse particles on which it should act. The mill faces also become wet by contact with the material being crushed and the clusters adhere to the metal. With repeated application of pressure these agglomerates become compactly grouped in rigid cakes into which the mill action no longer penetrates. The walls of a ball mill become coated quite deeply; and the balls, having little charge mixed with them, move on the surface of this cake. There is little tendency for drying to take place.

If the mill friction is low, there is but a small amount of heat generated and the atmosphere is soon saturated. In the case of extreme friction if the mill actually reached atmospheric steam temperature, free water would boil away, but the drying of the material being ground would be very slow. However, it takes still higher temperatures than 212 deg. F. to eliminate water completely from the material, for sorbed moisture is held well beyond the equilibrium temperatures for evaporating free water. The actual amounts of moisture required to impede grinding vary with the material, its fineness, and the manner of mill loading. Fig. 3 shows that mill capacity is reduced more than one-half for the three materials shown when their moisture values are in the range of 10-15 per cent. Hence for all practical considerations it was necessary to operate the ordinary grinding mill with either very wet or very dry feed.

In mills where the material is dried during the process

of grinding the effect of moisture is greatly reduced; for although the feed is wet, the material within the mill is essentially dry. Moist solid entering from the feeder may behave for a short time as it would in a closed mill. The dry solid already in the mill adheres to the surface of the moist material and removes the water by a blotting action. As the sticky feed becomes dried by diffusion of water to adherent material, the mass becomes more crumbly and disintegrates into smaller lumps. These are mixed with more dry material until finally the individual pieces of feed material are essentially freed of water. The action of the machine hastens the mixing of the feed with the drier material already present and quickly produces a uniformly dry condition of the material held within the mill. At the same time the feed material is warmed, and the vapor pressure of the water in it is increased to such a point that appreciable amounts of water are evolved into the overlying air.

This processing then brings the material to a condition where the mill action on individual particles can take place with a minimum of agglomeration. While not entirely dry, the material is in such a condition that the fine particles do not adhere too much to the coarse ones; also there is sufficient fluidity to the mass so that the fines flow from beneath the mill loading, exposing the coarse ones to direct action. Under these conditions the fine particles move freely and are lifted out of the mill by the air stream. In the air separator the coarsest of these are returned by gravity or centrifugal force, while the finer material passes on to the product collectors. During the process of removal further drying takes place, thus reducing the product to a very low moisture content.

### Behavior of Moisture During Drying

It is necessary at this time to consider in some detail the behavior of moisture during the drying of a material. Recent work on the drying of solids shows that there are three stages involved in the drying of a piece of moist material. As the air sweeps over the surface of a solid, vapor is evolved into it from the free liquid film. The relation is not unlike that which would exist if air swept over an open container of the liquid. The mass being dried is automatically cooled toward its dew point and the vapor pressure of the liquid is reduced. The evaporation proceeds in the same manner, only more slowly. After a time certain faces of the material become freed of liquid, while others are still moist and the evaporation rate drops. As soon as all of the free moisture is eliminated from the surface, the liquid in the interior of the mass must diffuse to the surface before it can be evaporated. This takes place very slowly and drying is much less effective under those conditions. The limit of drying is reached when the water is reduced to the equilibrium moisture content of the material.

It is well known in the field of drying that there is a certain percentage of water retained in the solid. It is small when the humidity is 0 per cent; quickly increases to a significant value when the humidity is around 25 per cent; slowly increases beyond that up to a humidity of 80 per cent; and then rises rapidly as the atmosphere approaches saturation. The variation in the absolute values has not been so fully studied under a wide variety of temperature conditions.

This equilibrium moisture sorption gains special significance in the field of grinding. Most of the materials being subjected to pulverization are inherently low in their tendency to sorb water into the particle, but they have large surface areas exposed after grinding upon which such sorption may take place. Some equilibrium moisture sorption values for ground sand and for zinc oxide are presented to show quantities of moisture retained under different humidity conditions and the effect of fineness upon this value (Fig. 4). Certain materials of a more colloidal nature may hold still larger quantities of moisture. It is reasonable to assume that this type of curve holds at the higher temperatures used in drying mills, and it becomes important to control the humidity of the atmosphere within the mill.

### Advantages of Warm Air

According to this concept it can be seen wherein grinding mills which are swept by warm air may offer distinct advantages in rate of drying, power consumption, and character of the product. The moisture in the feed is quickly spread through a large mass of material which is warm and essentially dry. The temperature and the greater surface accentuate the drying, leaving a dry material to be subjected to grinding action. The marked lowering of mill capacity revealed in Fig. 3 is affected only in a minor way on account of the low moisture content of the solid in the mill.

The mechanism by which rapidity of drying is achieved

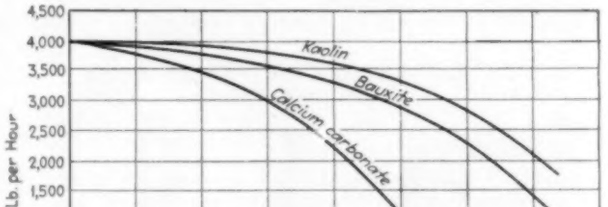
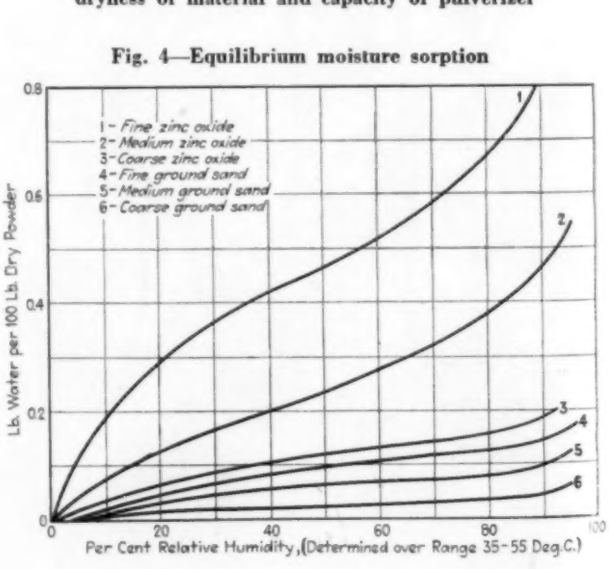



**Fig. 3—Test-chart showing relation between dryness of material and capacity of pulverizer**

**Fig. 4—Equilibrium moisture sorption**



can be supplemented to show how a uniform product is obtained. It has been shown that fine particles dry quickly. In contrast, consider the drying of a filter cake which has already been mentioned as a striking example of the performance of the drying mills. The area is small per unit of mass to be dried and there are long distances for the fluid to diffuse through the solid in order to reach the surface. If there are dissolved solids in the fluid, these will travel to the surface and produce incrustations or efflorescence, and the cake becomes non-uniform in composition. Such incrustations are more difficult to grind and have a tendency to leave grits in the finished product. The process of grinding an already dry filter cake tends to make the product uniform, but the combination of drying and grinding is more likely to insure uniformity. The decomposition of hydrates presents a more delicate situation where the drying mill is effective because of close temperature control and rapid penetration of heat. The small particles may be brought to the correct temperature without danger of over or under heating which commonly occurs in the processing of large masses.

Since the combination of drying and grinding have been effected a number of applications have been made ranging from mineral products to sensitive organic materials, and from coarse wet masses to plastic materials like filter cake. The combination takes advantage of the principles of drying to produce results rapidly and with little if any impedance to grinding. Due to the intimate contact of the material with air, and the close temperature control which may be maintained a high quality of product can be secured.

# Producing Glass From Furnace Slag

By C. A. BASORE

*Professor of Chemical Engineering*
*Alabama Polytechnic Institute, Auburn, Ala.*

BLAST FURNACE slag as a raw material for glass has interesting possibilities. The slag serves as a cheap source of lime, alumina and silica. Cheap building sand can be used for the additional silica needed. Expensive glass sand is unnecessary. Furthermore, experimental results seem to indicate that liquid slag as it is discharged from the blast furnace can be converted directly into glass. In this way an appreciable saving of fuel should be secured. The nature of the various glasses made from the slag is such, that these glasses preferably would be molded or pressed which would require the minimum in initial and operating expense.

The comparatively large amount of iron oxide in the slag and the sand (1 per cent or more) mitigates the possibility of making colorless glass, but pale green to medium or dark green, brown or black is readily made as desired. In most cases the glass has a sheen or gloss, and a depth of color which is quite attractive. The black glass is jet black in color and has a high gloss which suggests its use for decorative purposes. In general, slag glass is tough. It draws readily into threads which are unusually elastic. When the glass breaks, it has a considerable tendency to break in rounded fragments rather than in angular pieces.

### Uses of Slag Glass

Several types of the slag glass have been developed on an experimental scale. The ordinary transparent type has been reported in Bulletin 3 of the Engineering Experiment Station of the Alabama Polytechnic Institute. A modification of this glass is semi-transparent or translucent, and might perhaps be defined as "opal" glass. This glass greatly diffuses the light, the outlines of objects observed through it being only visible for a distance of two or three feet. It appears that this glass might serve as an inexpensive substitute for the opal glass employed for windows and doors of offices, lavatories, and factories.

The various slag glasses have been suggested for many purposes. The transparent glass has a relatively low coefficient of expansion, high tensile strength, good thermal endurance, and excellent resistance to corrosion agents, such as boiling water, hot sodium hydroxide solution and boiling hydrochloric acid. Therefore, it is suggested for making bottles, jars and similar objects, and also for linings for kettles, tanks and other pieces of chemical equipment. The glass might be used in building and construction for glass floors, tiles, and the like.

The black glass is believed to be suitable for floors, tiles, wainscoting, and pilasters of buildings, for blackboards, door knobs, and similar articles. It is also believed to have a future for the production of vases, table tops, and as a substitute for black marble. The chemical glass might be employed to advantage for laboratory glassware not subjected to great temperature changes where toughness, high tensile strength, and good resistance to corrosion is of value.

## Fired Clay Materials

At the Columbus station of the Bureau of Mines, in the study of the glass phase in fired clay materials, a number of glasses have been prepared in the four-component system $K_2O.CaO.Al_2O_3.SiO_2$. The surfaces of the tetrahedron representing this system are composed of the following three-component systems: $K_2O.Al_2O_3.SiO_2$, $CaO.Al_2O_3.SiO_2$, $K_2O.CaO.Al_2O_3$, and $K_2O.CaO.SiO_2$, all of which are of ceramic importance. Glasses whose compositions are represented by points within the tetrahedron are formed whenever mixtures such as flint, feldspar, whiting, and china clay are subjected to high temperatures. A knowledge of the properties of all these glasses in the tetrahedron would be of considerable value to ceramists.

At present the portion of the tetrahedron lying between the 50 per cent and 80 per cent silica levels is being investigated. A preliminary study using cones, was made to obtain some idea of the fluidity of these glasses.

# A. G. A. Discusses New Methods Of Producing Water Gas

EDITORIAL STAFF REPORT

MANUFACTURE of gas has not been made obsolete by natural gas invasion. Nor has the need for new engineering development in this field waned. These facts are clearly evident from the Production Conference of American Gas Association held May 22 and 23 in New York City. This, the first such meeting after a two-year interval, provided four technical sessions attended by approximately 300 engineers and chemists of the industry.

Numerous subjects of peculiar interest and importance to gas men were considered. Among them were three, each represented by groups of papers, having broad chemical engineering importance. These related to (1) the manufacture of water gas of unusual properties for mixing with natural gas; (2) new types of underfiring of coke ovens and the reduction of breeze made at ovens; and (3) improved methods for removal of sulphur from gas.

### Water Gas for Mixing

Natural gas has invaded the greater part of the United States for city supply. In many localities it is mixed the year round with some type of manufactured product before distribution. However, in most cases it is supplied without mixing. And even in these communities the problem remains of eking out limited supplies during periods of peak demand or substitution on short notice in the event of breakdown in natural-gas transmission or supply facilities.

Water gas must be so used frequently both as a standby for emergency and for peak-load additions. But normal types of water gas cannot be occasionally mixed with natural gas except in limited quantities without changing the burner performance enough to interfere with both household and industrial use. The problem of making gas that can be so added has, therefore, engaged the attention of a large part of the manufacturing division of the industry. The results of these efforts were presented in about ten reports dealing with new methods of manufacture, new processes, or other phases of the mixing problem.

The Water Gas Committee, under L. J. Eck, chairman, presented a progress report supplemented by summaries of specific tests in various localities, including the Hunts Point Works of Consolidated Gas Co., New York City, the use of oil-refinery gas at the Green Point plant of Brooklyn Union Gas Co., and experiences in substitution of mixed gas during peak load of the Pacific Gas & Electric Co.

Higher B.t.u. gas than normal made in standard water-gas sets was reported on by engineers of both Chicago and Philadelphia. A striking conclusion of the Philadelphia investigations, as summarized by W. K. Beard, was the evidence that carburetted gas of more than 700 B.t.u. per cu.ft. can be made at a slightly lower cost per heat unit for solid fuel and oil than is attainable in standard operation with 530 B.t.u. gas. Beard also concluded that no complications from smoke, tar, or other difficulties were introduced and only minor changes in operating methods were required. The results indicate that still higher heating values than attempted in Philadelphia are easily obtainable, but no evidence was gained as to the upper limit which can be safely reached.

Chicago investigations indicated similar conclusions with definite evidence that up to 900 B.t.u. gas can be manufactured at approximately 160 M cu.ft. per machine-hour with a simple operating cycle. It was discovered that the therm output per machine is materially greater with rich gas than with that ordinarily made (of 520 B.t.u.). The only complication reported was slightly greater frequency of rechecking, the intervals dependent on the quality of oil used.

K. B. Nagler, describing one phase of the Chicago investigations, drew the following conclusions: The increase in B.t.u. was obtained by decreasing blue gas in the mixture, through lower steam input. The solid fuel consumption is unchanged. Oil consumption is increased from 3 gal. for 530 B.t.u. to 7.5 gal. for 800+ B.t.u. The tar yield is greatly increased, from 0.2 to 1.1 gal. per M. The oil efficiency is reduced from 100,000 B.t.u. per gal. to 85,000 or 90,000. The increase in therm capacity per machine-hour ranges from 15 or 20 per cent for large machines to 50 or even more on small units.

As an evidence of the characteristics of gas made and fuel efficiency obtainable under comparable conditions, Nagler presented the following data in which gas A is that normally used for mixing in Chicago; gas B that formally made when candlepower of send out was 23.5; and gases C, D, and E, experimental production made in attempt to match the natural gas-water gas mixture now commonly distributed in Chicago.

A special subcommittee under E. L. Fischer, chairman, investigated experimentally at Mason City, Iowa, two methods of producing rich water gas: (1) production of a highly carburetted gas of about 40 per cent by volume of blue gas and 60 per cent oil gas; (2) production of a straight oil gas using producer gas from the generator merely for heating the checker work.

The committee obtained in the best runs on straight oil gas about 4 hr. operation with a make of 20 M cu.ft. per hr., from 24.5 lb. of coke, 12.85 gal. of oil, and 24.5 lb. of steam per M. The average B.t.u. was 999, and the specific gravity of the gas 0.575. The cost of materials involved was approximately 62c. per M. In these runs it was found necessary to shut down at short intervals, because the offtake pipe of the generator became choked with lampblack, because this pipe was smaller in diameter than desirable for this sort of operation.

From their heavily carburetted blue-gas runs of about 6 hr. they made 22.8 M cu.ft. per hr., with fuel consumption of 25.3 lb. of coke, 12.05 gal. of oil. and 27.1 lb. of steam per M. The gas made was 1025 B.t.u. per cu.ft. and of 0.726 sp.gr. The cost of materials was approximately 59.5c. per M.

From the tests made the committee draws a series of important conclusions, among which those of general interest are:

1. Gas can be made in a standard carburetted water-gas set without changes of any kind, which will serve as a substitute for natural gas and will burn satisfactorily in any appliance properly adjusted for natural gas without changing the adjustment of the appliance, either when mixed with natural gas in any proportions or when substituted 100 per cent.

**Characteristics of Gas Made and Fuel Efficiency Obtainable Under Comparable Conditions**

| | A | B | C | D | E |
|---|---|---|---|---|---|
| B.t.u. | 540 | 695 | 811 | 826 | 850 |
| Gal. Oil/Mcu.ft. | 3.0 | 4.23 | 7.48 | 6.34 | 8.58 |
| Lb. Fuel/Mcu.ft. | 30.0 | 30.82 | 32.12 | 28.83 | 31.95 |
| Lb. Steam/Mcu.ft. | 30.0 | 30.90 | 20.02 | 25.10 | 19.80 |
| $CO_2$ | 3.4 | 4.3 | 1.8 | 2.7 | 1.6 |
| Illum. | 8.4 | 12.6 | 19.7 | 19.1 | 18.9 |
| $O_2$ | 1.2 | 0.7 | 0.3 | 0.3 | 0.2 |
| CO | 30.0 | 30.2 | 25.7 | 22.3 | 21.3 |
| $H_2$ | 31.7 | 29.3 | 29.2 | 27.6 | 28.0 |
| $CH_4$ | 12.2 | 17.8 | 13.5 | 19.7 | 20.7 |
| $C_2H_6$ | .... | .... | 5.2 | 3.6 | 4.3 |
| $N_2$ | 13.1 | 5.1 | 4.6 | 4.7 | 5.0 |
| Sp.gr. | .64 | .... | .70 | .69 | .69 |

2. A satisfactory substitute for natural gas must contain not more than 35 per cent by volume of combined carbon monoxide and hydrogen and with these percentages must either (a) have approximately the same B.t.u. value and specific gravity as the natural gas, or (b) the heating value may be less than that of the natural gas if the specific gravity is sufficiently lower than approximately the same B.t.u. delivery per hour through the burner orifice results. If a gas with a lower combined percentage of hydrogen and carbon monoxide is produced, then the heating value may be lowered provided the specific gravity is not greatly increased.

3. The temperature of gases leaving the set is the best indicator of the quality of the gas being produced. When making straight oil gas, this temperature variation is the only means of controlling B.t.u. and quality. The temperature of the gases leaving the set is the result of three possible variables, viz.: a temperature of brick at bottom of superheater, rate of oil input, and rate of steam input. For a given rate of oil and steam per minute definite relations will be found between the temperature of the outlet gas and the temperature at the bottom of the superheater. Once this relation has been established and the desired outlet gas temperature determined for the particular quality of gas desired and for the particular oil used, very constant results can be obtained by operation on a combination temperature time cycle as follows: (a) Blast of sufficient length that the temperature at the bottom of the superheater reaches the desired maximum. (b) A run of definite time period with definite rate of oil and steam allowing time for a steam purge after shutting off the oil.

### Carburetted Blue Gas

4. In making carburetted blue gas it is advisable to follow the same procedure as to cycle and temperatures as for straight oil gas although a constant B.t.u. of gas can be made by varying the blue gas-oil gas ratio. Constant B.t.u. value, however, is not in itself sufficient as the constituents of the gas are also important. The best operation as to constancy of gas is obtained by constant gas outlet temperature and it is recommended that the temperature-time cycle be followed for this method also. It is necessary to determine the proper temperature of the outlet gas for each machine and each grade of oil. This temperature should be the highest temperature that can be used without lampblack production; in other words, the maximum cracking obtainable for the particular oil used without hydrogen production. This should give maximum oil efficiency, maximum methane production and minimum production of illuminants possible without hydrogen production.

5. Proper operation will require two pyrometers, one located at the bottom of the superheater and one in the connection between outlet of superheater and washbox. For best results a two-pen recording pyrometer showing the temperature at both points is recommended.

6. For blue gas-oil gas mix no changes of any kind are required to the set unless for a particular plant it is found that the oil spray and pumps are too small to supply the required rate of oil flow.

7. For the production of straight oil gas it will be necessary to provide means of keeping the offtake pipe and washbox clear of lampblack if continuous operation is to be maintained as during the tests there was an accumulation of lampblack sufficient to force shutdown after about five hours run. The effect on this condition when using gas oil was not determined.

8. Straight oil gas can be substituted successfully with lower B.t.u. values than blue gas-oil gas mix because of the lower specific gravity and lower percentage of illuminants.

9. Results of tests indicate that the reduction in B.t.u. value due to compression and cooling is about the same for the two gases.

10. The capacity of the set when making straight oil gas (assuming provisions for disposal of lampblack as mentioned above are made) is approximately 9 per cent less (on a volume basis) than the capacity of the set when using coal and producing 600 B.t.u. carburetted blue gas.

11. The capacity of the set when making blue gas-oil

gas mix of approximately 1,050 B.t.u. is approximately 3½ per cent greater than the set capacity when producing 600 B.t.u. carburetted blue gas.

Both of the above are based on using fuel oil for the high B.t.u. gas and gas oil for the 600 B.t.u. gas.

12. It is believed that higher capacities may be realized with either method of operation when using gas oil instead of fuel oil.

### Recirculated Oil Gas

Investigations under E. S. Pettyjohn, research engineer at the University of Michigan, have resulted in the development of a new oil-gas process which has been christened "the recirculated oil-gas process." The object of this method is to make the highest possible heating value by oil cracking in a standard water-gas machine, without conversion of any part of the oil into hydrogen and lampblack. Elimination of this complete cracking does two things of advantage: (1) It prevents lampblack troubles which are serious in water gas equipment; (2) it prevents addition of hydrogen to the gas, with a consequent lowering of both heating value per cubic foot and specific gravity, both of which changes are undesirable when the product is to be mixed with natural gas.

Pettyjohn describes his process as follows:

The recirculated oil-gas process was designed to provide both the necessary control of time of contact and of temperature to produce a gas of high methane content without the formation of lampblack. The oil to be cracked is atomized into the top of the carburetor through a standard type oil spray. The atomized particles are vaporized and partially cracked as they are carried rapidly forward by steam superheated in the checkerbricks which have been substituted for the fuel bed in the generator to increase the available heat storage capacity. As this mixture reaches the base of the carburetor part of it is withdrawn through an auxiliary line and recirculated through the generator and carburetor increasing the velocity of the atomized oil particles through these high-temperature zones. The remainder of the partially cracked oil vapor passes upward through the superheater at a rate which allows a longer time of contact in this lower temperature zone. By varying both the portion of the oil run during which the partially cracked oil gas is recirculated, and the quantity recirculated through changing the volume of steam admitted to the aspirator, the quality of the finished gas may be controlled.

The tar that is formed is separated from the gas stream in the usual manner and is returned to the generator through a bustle pipe and burners to provide the heat for oil cracking. Any excess above the quantity necessary for warming-up the machine and for combustion during the blast may be returned to the generator through a spray in the charging cover. In this manner, the single byproduct of the process is eliminated.

In water-gas plants which have been partially abandoned, the generation of steam may be extremely costly and impracticable. When this condition obtains, the recirculation may be accomplished by compressing and admitting a small quantity of the finished gas to the aspirator. As no water gas is made, the only process steam required is for purging the set and it is believed that this purging can be accomplished with water sprays.

High-pressure air is a more satisfactory tar atomizing medium than steam, and with water for purging and when motor driven blowers and exhausters are used, steam generating equipment is not essential.

Operated without a fuel bed, without steam other than that generated within the machine, without either lampblack or tar as byproducts, the recirculated oil-gas process offers distinct possibilities as an economical method for converting abandoned carburetted water-gas sets into stand-by equipment for meeting peak loads and failures of supply in natural gas territories.

The essentials for successful operation in addition to carefully controlled recirculation are: (1) A tar burner which will give complete combustion and which will not seep during the make period; (2) The maintenance of temperatures in the superheater within the range of plus or minus 25 deg. above or below 1475 deg. F.

The results obtained in this initial test are distinctly favorable and indicate that the recirculated oil-gas process does provide a suitable method for the utilization of abandoned carburetted water-gas equipment in the production of a high-heating-value oil-gas as a substitute for natural gas during peak loads and during failures of supply.

Operating results obtained in these investigations were satisfactory. Requirements were approximately 10.8 gal. of oil and 2.7 gal. of burner tar, with 10.6 lb. of steam per M. The make in a 10-ft. standard water-gas machine was approximately 86 M cu.ft. per hour of gas, having the following analysis and characteristics.

| | With back-run tar | Without back-run tar |
|---|---|---|
| $CO_2$ | 2.6 | 3.4 |
| Illuminants | 24.2 | 30.0 |
| $O_2$ | 0.4 | 0.8 |
| CO | 2.8 | 2.0 |
| $H_2$ | 31.0 | 26.0 |
| $CH_4$ | 33.8 | 36.8 |
| $N_2$ | 5.2 | 1.0 |
| Observed heat value | 1,030 | 1,100 |
| Observed specific gravity | 0.726 | 0.738 |

The outstanding conclusions from the investigation are expressed by the author as follows:

From these results it may be seen that the recirculated oil-gas process may be used to produce a high heating-value gas which may be mixed with and substituted for natural gas in appreciable quantities for short periods of time. The upper limit was not determined, but it is believable that complete substitution is possible.

Eleven-hundred B.t.u. gas was made with less than 11 gal. of oil per M. cu.ft. It is believed that this quantity can be reduced with additional operating experience provided the byproduct tar is used for underfiring the machine.

All of the tar produced by the process may be returned to the generator as either heating-up tar, burner tar, or back-run tar. There are no other byproducts or waste products. The process was operated with less than 11 lb. of steam per M. cu.ft. of gas made. It is believed that this quantity can be reduced, if not eliminated, by generating the process steam within the machine.

The modifications to the standard three-shell water-gas machine are both easily and inexpensively made and can be installed or withdrawn in a reasonable length of time. The process can be operated with a minimum quantity of labor as with automatic control and hydraulic operation one gas maker per shift is sufficient.

# With the Chemical Engineers In Chicago

## EDITORIAL STAFF REPORT

TECHNICAL sessions of the twenty-fifth semi-annual meeting of the American Institute of Chemical Engineers, held in the Medinah Athletic Club in Chicago June 14, 15, and 16, centered largely around symposia on high pressure technique and measurement and control in chemical industries. Abstracts of some of the papers are given in the following paragraphs. Dr. Easterwood's paper appears elsewhere in this issue and others will be reviewed or published in full in July and August.

John L. Cox, chief engineer of The Midvale Co. of Philadelphia, presented two problems in materials of construction made important by the growing commercial requirements for high pressures and temperatures, especially in dealing with hydrogen. He discussed the gradual continuous distortion of metals under continued load below that producing prompt fracture—making it unsafe to use at elevated temperatures the usual rules of design based on tensile strength or proportional limit.

He stated that a short run at high temperature is more destructive than a much longer run at lower temperatures. If then, a piece of apparatus need have but a short life, a high stress can be used, but if the life must be long it will pay to use heavier sections with lighter stresses, in spite of increased first cost.

The growing use of hydrogen at elevated temperatures and under pressures running up to 15,000 p.s.i. has added another difficulty to the problem of securing satisfactory materials for high-temperature service. In service the 24 per cent chrome—20 per cent nickel alloy has been exposed without failure for many thousands of hours to high-pressure hydrogen at temperatures as high as 440 deg. C., B.T.G. metal is regularly used at temperatures as high as 565 deg. C. under pressure of 1,000 atmospheres of hydrogen, with a fiber stress as high as 25,000 p.s.i.

Up to the present time, the handling of high pressures in chemical synthesis has been largely a rule of thumb development of experience in other fields. Dr. R. V. Kleinschmidt of Arthur D. Little, Inc., declared that some of the most important problems, however, provide a fertile field for application of basic physical principles. In this paper no attempt has been made to survey the entire field, nor is it intended to follow all of the details of design of any one piece of equipment. Five items have been selected as illustrative of the results that may be expected from careful analysis of fundamental conditions, as well as for their immediate applicability. These are closures and gaskets; valves; the effect of compressibility factors on compressor design; thermal limitations of converters; and some principles of heat transfer applicable to catalyst bed design.

In discussing the control of chemical processes, John J. Grebe, Ray H. Boundy, and Robert W. Cermak of the physical research laboratory of the Dow Chemical Co. stated that the accurate measurement and control of the variable factors of chemical processes will pay dividends in a direct and obvious manner if their existence is justified economically. Chemical processes can not operate without control, but a careful analysis of economic factors is necessary in order to determine whether manual control should be replaced with automatic controls.

They emphasized that a plant should be built around its controls rather than attempting to build the control around the plant. That is by far the most important feature in controlling a new plant. No control, no matter how perfect, can take the place of proper plant design. The effect of time lag can be compensated for, but never eliminated in a control. That can be done only in plant construction. When the number of controls in one plant are quite large, it is good practice to centralize the controls in one room. This makes maintenance easier.

George A. Perley of Leeds & Northrup Co. of Philadelphia reported that the chief purpose of his paper was to present the advantageous features of modern methods of pH measurement and control and to stress the limiting conditions of usefulness of these methods. In the determination of the pH of a particular industrial solution there is doubtless one method which is better adapted to the conditions than are the other possible means of measurement.

The continuous measurement of gas composition was the subject of a paper by William F. Hamilton, formerly director of research, Charles Englehard, Inc., and now in the automotive engineering department of the Richfield Oil Co. of California. He pointed out that recently considerable industrial use has been made of gases for commercial synthesis or reaction, owing to the ease of handling gases and the flexibility of control of gaseous reactions, these processes are for the most part continuous, or semi-continuous. Discontinuous methods for determining the composition of gases are fast becoming replaced by continuous, automatic, and more rapid methods.

### Cooperative Research at Illinois

The advantages of the thermal conductivity cell for the continuous measurement of gas compositions are: flexibility of application, time lag easily controlled, accurate control of composition, rugged construction, portability, remarkable sensitivity, and automatic control easily operated.

Cooperative research in chemical engineering at the University of Illinois has been confined to fundamental industrial problems in various fields, according to Prof. D. B. Keyes, head of the chemical engineering division of the university. The problem must be of a broad nature so that more than one industrial concern is interested and preferably more than one industry. It must be of such a fundamental nature that the research organizations of the particular cooperative industry are not equipped to handle the problem, principally due to lack of time at their disposal and, secondly, because of inadequate staff.

David E. Pierce, chief engineer of Charles Lennig & Co. of Philadelphia outlined the rôle of the semi-works plant in an interesting paper appropriately titled "The Half-Way House." Besides its well known function in finding the "bugs" and working the "kinks" out of laboratory process, the semi-works plant serves as a valuable training ground for plant operators.

# OTHERS' VIEWS

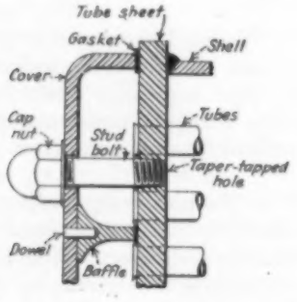
## Staying Heat Exchanger Heads

*To the Editor of Chem. & Met.:*

Sir—In the April number of *Chem. & Met.*, p. 205, Bernard Kramer describes a method of staying the head, or cover, of a heat exchanger. The stay bolt is tapped into the tube sheet which has a pad, or boss, welded to the inside in order to obtain the required length of thread without entering the pressure space. Where the stay passes through the volume inclosed by the head it is surrounded by a sleeve which is integral with the cover, and the other end bears on a gasket on the tube sheet.

The construction described serves the purpose, of course, numerous applications of the method attesting to that, but unless the baffle and bolt must necessarily be in line, it seems like a complication. Some years ago I saw such a method applied to the head of a welded steel exchanger and, to quote a commentor, "It seemed to have a half-mile of welding."

In the sketch accompanying this is the alternate method of staying the head of the heat exchanger, referred to in the opening paragraph of Mr. Kramer's letter. The purpose of the through bolt




**Taper tap and cap screw make this method of staying fluid tight**

illustrated in my article of December is to get the benefit of the additional tube when close spacing is desired for the sake of economy, or for other purposes. As shown in the sketch, the bolt hole in the tube sheet is taper-tapped 12 threads per inch. The stud, however, has a straight, or parallel, thread and, when screwed into the tapered hole "jams" in and makes a fluid-tight connection; the method is familiar boiler-shop practice. The cap nut, bearing on the cover, makes the other end of the bolt fluid tight. The nuts on the studs located away from the flange of the cover are set up only slightly, but when the pressure is applied to the exchanger, that part of it carried by the stud bolt is more than enough to make the nut fluid tight.

C. O. SANDSTROM

Thermal Engineering Co.,
Los Angeles, Calif.

## Dilution of Shellac Varnish

*To the Editor of Chem. & Met.:*

Sir—In the March number of your journal, W. H. Gardner describes the application of Schmidt's dilution formula to the problem of thinning down a shellac varnish to a definite strength of pounds of shellac per gallon of alcohol.

It is commonly known in the trade that 10 lb. of shellac bulks up as one gallon when cut in alcohol. If a 6-lb. cut is made by adding 60 lb. of shellac to 10 gal. of denatured alcohol and stirring until dissolved, the resulting varnish will have a volume of 16 gal., and the cost of materials per gallon of finished shellac varnish may be readily computed on this basis.

Based on these data, which are quite accurate, and taking Gardner's problem of diluting 60 gal. of a 6-lb. cut of shellac varnish to a 4-lb. cut, the answer can be easily found as follows and without considering the specific gravity of alcohol.

If 60 lb. of shellac dissolved in 10 gal. alcohol makes 16 gal. of product, then each gallon of this varnish contains 60 divided by 16, or 3.75 lb. shellac per gal. Therefore, 60 gal. would contain 60 multiplied by 3.75, or 225 lb. of shellac, which has bulked 22.5 gal. Subtracting 22.5 from 60, it is evident that 37.5 gal. of alcohol is contained in the 60 gal. of varnish.

If a 4-lb. cut is wanted then the 225 lb. of shellac would have needed 225 divided by 4, or 56.25 gal. of alcohol. Deducting 37.5 gal. from 56.25 we find 18.75 gal, as the requisite volume of alcohol needed to convert 60 gal. of a 6-lb. cut to a 4-lb. cut.

This result agrees closely with the 18.8 gal., as calculated by Gardner's formula.

A. C. LANGMUIR

Research and Consulting Chemist,
Hastings-on-Hudson, N. Y.

## Should Cast Iron Pipe Flanges Be Specified?

*To the Editor of Chem. & Met.:*

Sir—Included in Mr. Sandstrom's valuable article on "Bolts and Flanges for Tanks and Heat Exchangers" in the Feb., 1933, issue (pp. 67-71), which contains much that text books on machine design sadly lack, there is an analysis of the stresses induced in a 6-in. extra-heavy 250-lb. W.S.P. cast-iron flange. Ordinarily such flanges are threaded and become component parts of a pipe assembly, as indicated in Fig. 1 (p. 67). In Fig. 3, however, the pipe has been omitted; and this omission, it appears to me, introduces an error in any consideration of threaded cast-iron flanges.

In pipe-shop fabrication, powerful machines are employed to screw companion flanges onto pipes in order to get a metal-to-metal joint. In field assembly the same result is usually achieved. The tapered pipe thread, acting as a wedge, undoubtedly induces a considerable tangential stress which tends to split the flange. Therefore, for complete analysis of flange stresses, the stress due to bolting should be combined with that due to screwing the pipe into the flange.

### Pressure Approximates Force Fit

It is reasonable to assume that the pressure on the surface of the pipe thread approximates that of a force fit for parts of the same size, *i.e.*, a force fit where a thin ring is forced into a much thicker one.

The usual practice for force fits is to allow 0.001 in. per inch of diameter. For an ordinary cast-iron ring, however, such an allowance will cause a maximum stress approaching the breaking strength, although within the limits of safety for high-strength cast iron. The successful use of threaded cast-iron flanges seems to bear out the statement by Merriman: "The indications of experience are that factors of safety for thick pipes under pressure may be much lower than for thin ones."

We may assume that an allowance of 0.0004 in. will obviate leakage in the pipe thread, and may make the further assumption that practically all deformation will be due to compression of the comparatively thin pipe wall. The unit

stress in the pipe wall is $p = Ee$ where $p$ = unit stress in lb. per sq.in.; $E$ = modulus of elasticity = $30 \times 10^6$; and $e$ = compression per inch of diameter. Therefore, $p = 30{,}000{,}000 \times 0.0004 =$ 12,000 lb. per sq.in.

This stress is less than half the elastic limit. (See "National Pipe Standard," p. 12, 1924 edition).

The pitch diameter of a 6-in. pipe thread is nearly 6.5 in. and the inside diameter is 6.065 in. The thickness of pipe wall, in which it is assumed that the stress is uniformly distributed, is $(6.5 - 6.065)/2 = 0.2175$ in. The unit radial pressure between flange and pipe is $w = 2\ pt/d$ where $p$ = compressive stress in lb. per sq.in.; $t$ = thickness of pipe wall, in inches; and $d$ = pitch diameter of pipe thread, in inches. Hence $w = (2 \times 12{,}000 \times 0.2175)/6.5 = 800$ lb. per sq.in.

#### Flange Comparable to Ring

The pipe flange may be considered as a thick ring, subjected to an internal pressure of 800 lb. per sq.in. Because of the effect of the bolt holes, the outside diameter may be taken as 10.75 in. Birnie's formula applies to cylinders subjected to internal pressure in such manner as not to induce longitudinal stress in the wall; hence its use would seem to be indicated. This is:

$$S = \frac{1.3\ D^2 + 0.7\ d^2}{D^2 - d^2}\ w$$

where $S$ = maximum stress due to internal pressure, in lb. per sq.in.; $w$ = internal pressure, in lb. per sq.in.; $D$ = external diameter, inches; and $d$ = internal diameter, inches. Hence $S =$

$$\frac{1.3 \times 115.6 + 0.7 \times 42.3}{115.6 - 42.3} = 1{,}960 \text{ lb. per sq.in.}$$

If the stress due to bolting up amounts to 3,000 lb. per sq.in., then, even though the foregoing figures may not be very accurate, it is obvious that the factor of safety for cast-iron flanges is not excessive, and that ferrosteel, cast steel, or forged steel should be preferable for flange material. Many engineers will not specify threaded cast-iron companion flanges for any pressures over 10 lb. and even then they will specify malleable iron for sizes from 2½ to 4 in.

F. E. Wertheim

Mechanical Engineer
Chicago, Ill.

## Mr. Sandstrom's Answer

*To the Editor of Chem. & Met.:*

Sir—Replying to Mr. Wertheim's letter I will say that the stress tending to burst the screwed flange was not overlooked, but was omitted because its discussion with inadequate space would be unsatisfactory.

Mr. Wertheim forgets that the allowance of 0.001 in. per inch of diameter, for the force-fits alluded to, does not presume that only one member takes the entire deformation—it is divided between the ring and the inserted member according to certain factors. He allows 0.0004 in. per inch of diameter for the "force-fit" in screwing up the flange and, for the sake of simplicity, assumes that the resulting deformation is taken entirely by the wall of the pipe. Of course, if there is no deformation of the flange there can be no stress—no strain, no stress.

If the flange and the pipe share the assumed deformation in proportion to their effective diameters, sectional areas and moduli of elasticities, in the manner illustrated by Mr. Wertheim, neglecting the effects of the bolt holes on the total elongation of the flange, the diameters of pipe and flange are 6.5 inches and 10.75 inches, respectively; and the proportion of the "force-fit" allowance carried by the pipe is 2.95 times that of the flange, or 0.000299 in. per inch of diameter of pipe, and 0.000101 in. for the flange. The corresponding stresses are 8,970 and 1,515 lb. per sq.in. But as the problem was stated in terms of allowance, or deformation, the added material between bolt holes would be effective in resisting elongation, so the stress in the flange as found above would be decreased and that in the pipe increased.

#### Force to Screw up Flange

If, as found by Mr. Wertheim, the radial pressure between pipe and flange is 800 lb. per sq.in., the total pressure on the circumference for an effective length of thread of 1.5 in. is $800 \times 6.5\ \pi\ 1.5 =$ 24,500 lb. The theoretical axial component of this force on a 60-deg. thread, neglecting the small effect of the pitch angle, is the force multiplied by the tangent of 60 deg., or 42,400 lb. But the mechanical efficiency of a screw thread of this kind is very low. Using the formula applicable to bolts, or $T = 2\ \pi\ FLn/1 + Dn$, in which $T$ is the axial load, in this case 42,400 lb.; $F$ the force applied to the end of the wrench, or pipe-tong $L$; $n$ the number of threads per inch, or 8; and $D$ the diameter of the screw, or 6.5 in.; we have $FL = 42{,}400\ (1 + 6.5 \times 8)/2\ \pi\ 8 = 44{,}800$ in.lb. A pipe-fitter can screw up a 6-in. pipe with a 48-in. tong; $F$ then becomes 44,800/48 = 933 lb. A small fraction of that force will do the work on a properly made (and clean) thread, so we must conclude that the assumed 800 lb. per sq.in. radial pressure, and the corresponding stress, is too much. Furthermore, while the lateral force resulting from screwing up a flange on a pipe increases the tensile stress in the hub fibers when the connecting bolts are tightened, it at the same time decreases the compressive stress in the face fibers. The net result is a kind of compensation.

#### Taper Adds to Complexity

So far we have neglected the taper which, if considered, only adds to the complexity. The total taper of a pipe thread is $\frac{1}{32}$ in. per inch of length, and the pitch of the 6-in. pipe thread is $\frac{1}{8}$ in. If we assume that the mating threads are so accurately made that they are in perfect contact just before applying the pressure intended to make them fluid-tight, one turn of the flange will cause a total deformation of 0.0078 in., or 0.0012 in. per inch of diameter—three times the allowance assumed by Mr. Wertheim.

The 6-in. flange is supposed to go on the pipe about an inch by turning it on with the hands. The so-called effective length of thread is about 1.5 in. The $\frac{1}{8}$ in. then moved up with the tongs produces an apparent total deformation of $\frac{3}{32}$ in., or 0.0048 in. per inch of diameter. Any such deformation would have to be taken by the steel pipe since a fraction of it would crack the cast-iron flange. We must conclude then, that the apparent deformation is merely an "ironing out" of tool marks and other imperfections; which suggests that the threads should be well made, and not least, clean. The greater ductility of the steel flange should be one of its best arguments, since ductility permits intimate contact with less damage.

If it were practical to make pipe threads and other surfaces of like use as accurate and smooth as the Johansson gages, then the only clamping force necessary would be that required to resist the pressure of the fluid tending to separate the two parts of the apparatus. All fluids, liquids and gas, have measurable viscosities, which implies that if the surfaces are sufficiently true they need not be in actual contact to prevent the passage of the fluid.

Strain measurements of a pipe flange are easily made, so anyone with the necessary equipment, together with the time and the inclination, might contribute some information on the subject.

C. O. Sandstrom

Thermal Engineering Co.,
Los Angeles, Calif.

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*Correction*—On page 260 of the May, 1933, issue of *Chem. & Met.* the Oliver-Beatty clarifier was referred to as a vacuum clarifier. It is a *pressure* clarifier.

# BOOKSHELF

## Chemical Engineering's Progress

TWENTY-FIVE YEARS OF CHEMICAL ENGINEERING PROGRESS. Silver Anniversary Volume of American Institute of Chemical Engineers. Edited by Sidney D. Kirkpatrick. Published for the Institute by D. Van Nostrand Co., Inc., New York. 387 pages. Price $4.00, plus postage.

ALTHOUGH a silver anniversary represents a comparatively short span of years in the whole history of chemical engineering, the first quarter of a century in the existence of the American Institute of Chemical Engineers is crowded with events of such far-reaching importance that no apology need be offered for a brief pause for retrospection. During these years the American chemical industry has risen from secondary ranks to take its place among the world's leaders. Chemical engineering has been transformed from a formless conglomerate of chemistry and engineering into the crystalline structure of a profession, recognized today as a definite branch of engineering.

Most of the men responsible for this development are still in active service and the Institute has had the good fortune to secure as contributors to this volume, many of our leading engineers—men whose professional experience covers the entire period under consideration, men who still, even while reminiscing, have their faces toward the future. Lack of space fortunately saves this reviewer from the dilemma of discussing the individual contributions. The names of the authors is perhaps the best guarantee that the subjects have been adequately covered:

| | |
|---|---|
| W. L. Badger | A. V. H. Mory |
| Lawrence W. Bass | William D. Mount |
| Charles Owen Brown | George Oenslager |
| Hal B. Coats | Horace C. Porter |
| John V. N. Dorr | S. T. Powell |
| Francis C. Frary | Mark E. Putnam |
| Edward C. Holton | George Richter |
| John C. Hostetter | Ralph W. Shafor |
| Henry Howard | Howard W. Sheldon |
| Martin H. Ittner | W. B. VanArsdel |
| W. S. Landis | Edward R. Weidlein |
| E. H. Leslie | Archie J. Weith |
| Arthur D. Little | David Wesson |
| Albert E. Marshall | Robert Spurr Weston |
| George P. Meade | Alfred H. White |
| Fred C. Zeisberg | |

Except for Dr. Little's opening chapter on chemical engineering research, the economic summary of the process industries by Drs. Weidlein and Bass, and Professor White's forward-looking review of chemical engineering education, the twenty-five chapters of this volume deal with the principal industrial fields and a few of the more important unit operations of chemical engineering. The list is far from complete and, as the editor points out in his introduction, the volume is not to be regarded as a carefully balanced and coordinated text book. Rather it is a collection of authoritative essays each interesting in itself and contributing something to the extremely broad picture of the whole development of chemical engineering in American industry. As such it is a volume that deserves a place in the library of every chemical engineer, in the reference rooms of research laboratories and in the schools and colleges where the young chemical engineer gets his first glimpse of what lies ahead for him in his chosen profession.

## Science in Ice-Making

TREATMENT OF WATER FOR ICE MANUFACTURE, Part II. The Production of Manufactured Ice at Low Brine Temperatures. By *Dana Burks, Jr.* Published as Bulletins 253 and 254 of the Engineering Experiment Station, University of Illinois, Urbana, Ill. 34 and 66 pages. No charge.

THE COOPERATIVE WORK between the Illinois station and the Utilities Research Commission, Inc. started in July, 1928, and continued for three years. The first publication of results appeared in September, 1930 (Bulletin 219). Since that time semi-plant scale experimentation with full scale freezing equipment has shown that water supplies containing as much as 1,300 p.p.m. of dissolved salts can be used successfully in modernized equipment. Further operations of the plant demonstrated that when the brine temperature was reduced to 6 deg. F. instead of the usual 16 deg. the freezing time was cut in half. But difficulties due to opaqueness and shattering of the ice were encountered and in Bulletin 254 the means of overcoming these handicaps and the economic limits of low temperature operation are indicated.

## Finding a Job

THE TECHNICAL MAN SELLS HIS SERVICES. By *Edward Hurst.* Published by McGraw-Hill Book Co., Inc., New York. 239 pages. Price, $5.

IF THIS BOOK gets into the hands of the 12,000 technical men who, according to the information service of the National Research Council, are now out of jobs, there is likely to be some lively competition in the job-hunting business. It will prove equally effective in the hands of the several thousand technical men who part company with our schools and colleges in June, 1933.

The author of this book, a graduate of M.I.T. and a manufacturing executive himself, believes that the methods of analysis and procedure studied in engineering courses can be applied in the highly specialized field of personal salesmanship. His book is not the conventional pep-stuff, but is stimulating and thought-provoking because it is factual. For the most part it is based on a number of cases in the author's own experience with chemists and chemical engineers, industrial, electrical and mechanical engineers.

Professor Schell, chairman of the Placement Committee at M.I.T., where the book was used last year in special manuscript form, writes the publisher: "We feel that this book relates itself to the needs of the engineer more closely than any other available material. It can be immensely valuable to any graduating chemical engineer, but even more valuable to the man who has had some industrial experience." The only criticism of the present reviewer is scarcely a valid one. The employer reading this book is likely to get an inferiority complex. Perhaps he deserves it.

## Artificial Silk

LES SOIES ARTIFICIELLES. By *H. de Leeuw.* Librairie Polytechnique Ch. Béranger, Paris, 1932. 445 pages.
Reviewed by *T. R. Olive.*

FAR MORE operating information and much more attention to the equipment used in the manufacture of the four types of rayon is found in Dr. de Leeuw's book than has heretofore appeared in the literature of artificial silk. This is true, at least, in comparison with the English language literature which is, unfortunately, somewhat barren in these respects. Correction of this earlier difficiency follows naturally from the fact that the author has had some 20 years of experience with the industry, during part of the time he was chief chemist for the Dutch Enka (A.K.U.) at Arnhem.

The method of treatment is somewhat novel. After a discussion of the properties of cellulose which goes farther than is generally found outside the specialized literature of cellulose, he launches into the preparation of pulp and linters, following this immediately with a very extended and highly illustrated discussion of the equipment used in spinning. His description of spinneret punching is much better than anything the reviewer has found in English. From the spinning he carries the silk through all subsequent

operations, always with the emphasis on equipment, but with particular attention to the theory of drying.

Then having disposed of the inspection and shipment, he returns to the conditioning of water, the control of nuisances, and finally to the chemistry, operating and manufacturing details of the four spinning solutions. Several pages are devoted to cellulose film production. The volume is completed with a section on dyeing and a chapter on the economics and statistics of the industry.

## Chemical Wisdom of the Ages

THE ELDER PLINY'S CHAPTERS ON CHEMICAL SUBJECTS. Part II. Edited with translation and notes, by *Kenneth C. Bailey*. Edward Arnold & Co., London, England, and Longmans Green & Co., New York. 299 pages. Price, $5.00.

Reviewed by *Jerome Alexander*

DR. BAILEY deserves the thanks and congratulations, not only of all scientists, but also of teachers of the so-called "Humanities" for completing so excellently the task to which he set himself eight years ago. For all too many years Science was an academic Cinderella, but even now, in many institutions of learning, there is insufficient appreciation of cultural subjects. A book like this shows how both may be united.

C. Plinius Secundus, who died while recording scientific facts about the great eruption of Vesuvius (79 A.D.), was an indefatigable worker, starting in before daybreak. His nephew, the Younger Pliny, informs us that "in the country it was only the time when he was actually in his bath that he was exempted from study." Of all his prolific writings we have only the *Historia Naturalis* in 37 Books, which filled about 2,000 Roman "volumes," and quoted nearly 500 authors. So important was this work, that in the year 23 A.D., when only 160 "volumes" had been filled, Larcius Licinus, Praetorian Legate in Spain, offered the equivalent of approximately $16,000 for it.

The present publication gives the original Latin on the left-hand pages, and on the right-hand pages a carefully made and well considered English translation, based on comparison of about 21 manuscripts. The copious notes in the rear occupy 140 pages and contain many items of interest, besides discussion of doubtful passages, with consideration of what other editors have said. The translation comprises parts of Books 34, 35, and 36, and deals with quite a variety of subjects, including metals and alloys, the art of winning them, and the use of compounds of them in medicine. There is also discussed the preparation and uses of "earths" and pigments in cosmetic use and in painting, and for building and building materials.

It is most interesting to note how many of the practices described by Pliny have survived to the present day—some of them came from much more ancient times, for about 1,000 years before Pliny the Egyptians had hardened iron by carburization and quenching. But "bluestone" ($CuSO_4$ crystals) is still often used in conjunctivitis; zinc oxide and sulphur salves are still useful; oil-whetstones still give keener edge that water whetstones, and barbers may still moisten their hones with saliva. Adulterations still exist, and so do the means of detecting them. "Shoemakers' Black" ($FeSO_4$, probably so called since it blackens leather tanned with tannic acid, or galls), is detected by a "test-paper" made by steeping papyrus in extract of gall-nuts.

The origin of some of the well-known commercial names of chemicals is made evident. Thus glassy crystals were termed "vitrum," whence our "blue vitriol," "green vitriol" and "white vitriol," as well as "oil of vitriol." Since both cupric sulphate and ferrous sulphate (as well as mixtures of both) were crystallized from oxidized chalcopyrite, which was a much used copper ore, green vitriol was also known as "copperas." Apparently, Bilbao in Northern Spain was long famous for its iron, as it is today.

One non-rusting variety of iron was preferred for nails in military boots. "Iron is protected against rusting by white lead, gypsum, and pitch. . . . It is said . . . that an iron chain still exists at the town of Zeugma on the Euphrates, which was used by Alexander the Great in bridging the river there. Those links which have been renewed are a prey to rust, from which the original links are quite free." Dr. Bailey points out that possibly this chain, put there in 331 B.C., may have been made from iron from India. The Delhi iron pillar has stood 1,600 years in the open without rusting, and R. A. Hadfield reports the following analysis of it: Fe, 99.72; S, 0.006; P, 0.114; C, 0.08; Si, 0.046 per cent. Such pure iron does not easily rust. To distinguish *pale lead* (Sn) from *dark lead* (Pb), the former metal, when molten, bursts a piece of papyrus by its own weight rather than by its heat. . . . "It occurs to one to marvel at the persistent experimenting of humanity, which has exempted neither dregs nor foulest residues from the most varied examination."

## From the Alchemist's Viewpoint

MODERN ALCHEMY. By *William Albert Noyes* and *W. Albert Noyes, Jr.* Charles C. Thomas, Springfield, Ill., and Baltimore, Md. 207 pages. Price, $3.

Reviewed by *B. H. Strom*

ALCHEMISTS' SEARCH for a Philosopher's Stone, capable of transmuting base metals into gold, and an Elixir of Life, imparting eternal youth, has its sequel in modern science. Although the dreams of the old investigators have not come true, the latest discoveries in connection with the structure of matter promise to lead to results of far greater benefit to mankind than those sought by the alchemists.

In their interesting discourse the authors have presented a clear outline of the modern concepts of the constitution of matter, mainly from the viewpoints of the physicist and the physical chemist. How the new ideas of the construction of the atom have led the chemist to an entirely new and useful explanation of the phenomenon of chemical combination is discussed in the chapter on valence. Radio chemistry, the effect of radiation on chemical systems is a branch of chemistry in rapid development, and a general account has been given of progress made in this and related fields. Recent discoveries of new elements and new applications of old ones are frequently directly traceable to an improved knowledge of atomic structure.

The final chapter, The Elixir of Life, which deals with the application of physics and chemistry in the treating and combating of disease is highly fascinating and full of human interest. The authors' expressed hope that the book as a whole may also be of interest to readers trained in other sciences than chemistry will undoubtedly be fulfilled.

## Heating Electrically

INDUSTRIAL ELECTRIC HEATING. By *N. R. Stansel*. Published by John Wiley & Sons, Inc., New York. 444 pages. Price, $5.

Reviewed by *J. A. Doyle*

IN SPITE of Mr. Stansel's modest disclaimer that this book is not intended to serve as a source of engineering data, it may be properly classified as a dependable source of much valuable technical information. It is extremely interesting from many different angles. In fact, it is an outstanding contribution to the literature of the art.

It covers many of the aspects of industrial electric heating practice in a very comprehensive fashion so that the solution of many of the problems involved in such practice is made quite clear to the average industrial reader.

The chapter on "Atmospheres of Resistor Furnaces" is particularly interesting because of its relatively popular method of treatment and because of the timely nature of the discussion. In light of the development actually effected in the field of electric heating at relatively high temperatures, such as forging and heat treatment of high speed steel, it would seem as though the field of usefulness for silicon carbide, carbon, and other ceramic resistors could be materially expanded along the

lines followed with the capable presentation of the field of usefulness for metallic resistors.

Direct resistance heating, as in the heat treatment of tubes accomplished by passing the current through the piece to be heat treated, might be further expanded in the interest of this phase of the development of the art. Although this is not strictly a furnace application, it is of importance in consideration of the subject as a whole. All told, Mr. Stansel has made a very able contribution.

## A Rational Approach To Motion Study

COMMON SENSE APPLIED TO TIME AND MOTION STUDY. By *Allan H. Mogesen.* McGraw-Hill Book Co., New York. 228 pages. Price, $2.50.

Reviewed by *Wm. H. Gesell*

THIS EXCELLENT book represents a very valuable and welcome addition to motion study literature since it combines in concise and lucidly written form the fundamentals and procedures with their practical applications.

Chapters 1 to 4, 8, 15 and 16 are written by the author, and contain a discussion of time and motion study, its history, scope and applications, the detailed description of plotting and evaluating the simochart and an exhaustive description of the apparatus and the procedure of taking the pictures.

The remaining chapters are specific applications of motion study in various industries and in education. Each is written by a different author and most of them have appeared before as articles in technical publications.

As the title implies, the book is concerned with a rational use of motion study. The timely warning against overenthusiastic and indiscriminate use of the motion picture camera is sounded. It is pointed out that all major faults of layout and equipment which can be seen without a film analysis of individual elementary motions should be corrected first. Frequently this analysis is sufficient for practical purposes and the additional saving which could be effected by micromotion study would not be justified by the expense entailed in making the study. The book proceeds accordingly from the fundamental operation, the process chart, through the time-process chart with the stop watch to the stop-watch analysis of motions of each hand and synthesis of both on the chart according to McNiece. This latter step represents the transition from what one might term macromotion study to micromotion study. It shows at the same time how much can be accomplished without the costly micromotion equipment and the long and involved analyses of films.

The question is often asked: Is the "average" or the "first class" performance to be taken as a basis? The answer is: While standard time as determined with the stop watch should be based on the performance of the average good worker, the logical subject for motion study is the "first class" worker, or rather several of them. Only the highly skilled worker will use the utmost economy in his motions, and a composite "best way" is better than one individual method. In analyzing performance it is also necessary to discriminate between skill and effort.

Throughout the entire book the great educational value of motion study is emphasized. The fact that it makes engineers, foremen and operators "motion minded" and makes them scrutinize every new operation from the point of view of motion economy is considered an even greater gain than the saving derived from the improvement of one individual process.

A somewhat different arrangement of the material with the "text-book" and the "practical" parts grouped separately and with the two chapters on taking and analyzing pictures closely together might have been more advantageous.

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## Flotation Chemicals

FLOTATION PLANT PRACTICE. By *Philip Rabone.* London, England: Mining Publications, Ltd. 141 pages. Price, 10s. 6d.

A SERIES OF LECTURES delivered by the author on modern flotation practice has been compiled in book form. They are not intended for the expert, but are designed to give a broad concept of the subject with no more detail than is necessary for the purpose; such cost and capacity figures as are needed for preliminary calculations in the field have been included.

In order to keep the content within reasonable limits all description of out-of-date equipment has been omitted; processes and flowsheets have been selected with the same consideration. Almost half the text has been devoted to crushing, grinding, and classification prior to the actual flotation treatment. The chapter on flotation reagents also goes into much detail. No bibliography has been included since those readers desiring detailed information are referred to more advanced works.

## Man's Debt to Metals

MAN AND METALS. By *T. A. Rickard.* Published by Whittlesey House, McGraw-Hill Book Co., Inc., New York. Two volumes, 1,068 pages, 108 illustrations. Price, $10.

Reviewed by *James A. Lee.*

PARTICULARLY interesting is it to learn that the inspiration which prompted Mr. Rickard to undertake the enormous amount of work involved in the preparation of "Man and Metals" came from H. G. Wells, his former fellow-student under Thomas Huxley. Mr. Rickard rightly believed that Wells' much read "Outline of History," "omitted to pay proper regard to the part that mining has played in the development of civilization."

Mr. Rickard is unusually well qualified to undertake the preparation of this book. He has served as a mining engineer in many parts of the world. He has lectured on mining geology at several universities, has served for three terms as state geologist of Colorado, and in 1931 was appointed consulting engineer to the U. S. Bureau of Mines. He has been editor successively of *Engineering and Mining Journal, Mining and Scientific Press,* and *The Mining Magazine.* This experience probably accounts for the technical accuracy and the interesting and entertaining style employed throughout "Man and Metals."

The title the author has selected is somewhat misleading for he has gone back beyond the age of metals and has covered the whole span of human history. The first chapter, The Ages Without Metals, begins "A million years ago" when "the footfall of man's oncoming could be heard faintly down the corridors of time." And much of the material in both volumes, such as the chapter on the use of coal in the world's workshops, concerns the non-metals. However, most of this work is concerned with the metals and the rôle of the various divisions of the mining industry in the development of civilization.

## Perfumer's Bible

PERFUMES, COSMETICS AND SOAPS, 4th Edition—Vol. 2. By *William A. Poucher,* Ph.C. D. Van Nostrand and Co., New York. 599 pages. Price, $9.

Reviewed by *George F. Richmond.*

FOUR EDITIONS in seven years, with progression in the size of each issue, emphasizes the popularity of this book. It is rightly styled "A treatise on practical perfumery" and aside from chapter 1 which devotes some twenty pages to the historical aspects of the subject, and the short chapter 4 on Odor Classification, it is eminently practical throughout.

The present volume follows the arrangement of the preceding one by dividing the text into Part I, Perfumery, and Part II, Cosmetics, but with additions to many of the chapters to bring the work up to date. One new chapter dealing with Fruit Flavors has been added.

The book is presented in clear type on excellent paper and is unusually well illustrated. The many interior views of the extensive factories of southern France devoted to the extraction of floral products are authentic and emphasize the importance and magni-

tude of an industry confined almost exclusively to the production of perfumery raw materials.

The index is incomplete: for example, there are many references throughout the text to specific uses of cocoa-butter but the index is no aid in locating them. On page 523 zinc phenyl sulphonate is referred to as "zinc sulphocarbonate." This is manifestly a typographical error and the only one noted. The description of brushless or latherless shaving creams seems entirely too brief in view of the importance such preparations have lately assumed.

Numerous statements without basis of fact are encountered throughout the text. This lack of reference to original sources raises questions in the mind of the reader. Furthermore, such omissions do not seem fair to a book of such other practical merit.

For a subject so greatly influenced by style trends, national practices and preferences the treatise as a whole contains a wealth of matter of value to the perfumer, the cosmetician and the essential oil chemist. It is undoubtedly the most valuable treatise on the subject in the English language.

### Physico-Chemical Reference

A TEXTBOOK OF PHYSICAL CHEMISTRY —Vol. I—By *J. Newton Friend*. Published by J. B. Lippincott Co., Philadelphia, Pa. 501 pages. Price $7.50.

Reviewed by *F. E. Schmitt, Jr.*

UNUSUAL in the field of texts is this book by Friend, a book valuable as well for reference as for study. It gives a comprehensive and well-ordered development of each subject from the fundamental discoveries up to and including significant investigations published during 1932. This extension of historic coverage to very recent date is a noteworthy feature. Further, both mathematical development and experimental attack are included—apparatus being sketched and briefly described wherever advisable, and all important formulae not only derived but checked by tabulation of relevant data. The author disclaims any attempt at exhaustive coverage or perfectly logical arrangement, meeting the latter difficulty by a complete index and numerous cross references in the text. Reference to important investigations is made by including name and year parenthetically in the text, which is also a departure from established precedent. The subject-matter ranges in normal fashion from fundamentals and the gas laws to solubility and colloids, leaving valence, atomic structure, thermo-dynamic and other purely physical phases of the subject for Vol. II. And the whole is written, with a skillful choice of significant material, in a clear, concise, style that makes for easy reading and reference.

CHEMIE DER ZEMENTE. By *Dr. Karl E. Dorsch*. Verlag von Julius Springer, Berlin, Germany, 277 pages. Price, 25 M. Recent advances and developments in the cement industry are discussed from a chemical and scientific point of view. A large amount of experimental data has been collected and correlated to throw the proper light upon the processes involved in this important branch of industrial chemistry. Among the important chapters of the book may be mentioned raw materials; reactions involved in the process of burning; technology of cement burning; technical properties of cement; the alumina cements; hardening ment; the alumina cements; hardening of cement; corrosion of cement. Much space has been devoted to the latest x-ray and spectrographic methods of studying the structure of the product.

DECHEMA MONOGRAPHIEN No. 48, Vol. V. By *Dr. Ernst Jantzen*. Berlin: Deutsche Gesellschaft für Chemische Apparatewesen, E. V., Verlag Chemie. 142 pages, illus. Price, 10 RM.—This monograph deals with fractional distillation and fractional extraction of dissolved compounds, treated from a theoretical as well as from a practical point of view. Although written principally for the laboratory worker, much of the material presented should be useful in plant design and operation.

LEHRBUCH DER CHEMISCHEN TECHNOLOGIE. By *H. Ost*. Revised by B. Rassow. Dr. Max Jänecke. Verlagsbuchhandlung, Leipzig, Germany. 912 pages, illus. Price, 19.80 M. After Professor Ost's death in 1931, the task of revising his excellent handbook of industrial chemistry has fallen upon his colleague, Doctor Rassow, who has enlisted the aid of many prominent men in the industry in the work. The chapters on cement and mortars, cellulose, and aromatic oils have been completely rewritten. Chapters which have been radically revised include sulphuric acid; caustic soda; chlorine; nitrogen compounds; fertilizers; alumina; explosives; mineral oils; artificial silk; and dyestuffs.

CHROMIUM PLATING. By *Edward S. Richards*. J. B. Lippincott Co., Philadelphia, Pa. 131 pages, illus. Price, $3.50. Chromium plating is of such recent origin that the literature on the subject is necessarily limited. The present book deals mainly with the practical side of the art; only a limited space is given to theoretical considerations. It covers thoroughly the plating shop and its equipment; polishing and rough-polishing; copper plating; nickel plating; chromium plate on aluminum, wood, plaster, glass, and other materials; finishing polish for chromium plating, and protection of the workers.

## GOVERNMENT PUBLICATIONS

*Documents are available at prices indicated from Superintendent of Documents, Government Printing Office, Washington, D. C. Send cash or money order; stamps and personal checks not accepted. When no price is indicated pamphlet is free and should be ordered from bureau responsible for its issue.*

*Standards Yearbook, 1933.* Bureau of Standards Miscellaneous Publication 139; $1.00. Résumé of Bureau investigations and of foreign and United States industry developments.

*Standard Samples Issued or in Preparation.* Supplement to Bureau of Standards Circular 398. Listing the types available and purchase requirements.

*Wages and Hours of Labor in Metalliferrous Mines, 1924 and 1931.* Bureau of Labor Statistics Bulletin No. 573; 10 cents. Statistical résumé.

*Wages and Hours of Labor in the Iron and Steel Industry 1931.* Bureau of Labor Statistics Bulletin No. 567; 15 cents. Statistical résumé.

*Foreign Tariffs and Commercial Policies During 1932*, by Henry Chalmers. Bureau of Foreign and Domestic Commerce, Trade Information Bulletin No. 812; 5 cents.

*Sperm Oil and Spermaceti Wax.* Mimeographed preliminary report of U. S. Tariff Commission, including President's order regarding changes.

*U. S. Rubber Consumption Survey, 1932.* Bureau of Foreign and Domestic Commerce, Rubber Division, Special Circular 3420; mimeographed.

*The Rubber Producing Industry in French Indo-China.* Bureau of Foreign and Domestic Commerce, Rubber Division, Special Circular 3413; mimeographed.

*United States Exports of Rubber Products.* Bureau of Foreign and Domestic Commerce, Rubber Division, Special Circular 3422; mimeographed.

*Explosive Shattering of Minerals*, by R. S. Dean and John Gross. Bureau of Mines Report of Investigations 3201; mimeographed.

*Growth and Development of the Nonmetallic Mineral Industries*, by Oliver Bowles and C. W. Justice. Bureau of Mines Information Circular 6687; mimeographed.

*Explosive Properties of Acetone-Air Mixtures*, by G. W. Jones and others. Bureau of Mines Technical Paper 544; 5 cents.

*Mineral Production Statistics for 1931.* Separate pamphlets from Bureau of Mines on: Asphalt and Related Bitumens, by A. H. Redfield, 5 cents; Lead, by E. W. Pehrson, 5 cents; Lime, by A. T. Coons; 5 cents; Mica, by B. H. Stoddard, 5 cents.

*Mineral Production Statistics for 1932.* Preliminary mimeographed statements from Bureau of Mines on: Fluorspar; potash; liquefied petroleum gases; aluminum; crude oil; zinc; gypsum; Indiana oolitic limestone.

*Location of Manufactures, 1899-1929*, by Tracy E. Thompson. Bureau of the Census; 10 cents. A study of the tendencies toward concentration and toward dispersion of manufactures in the United States.

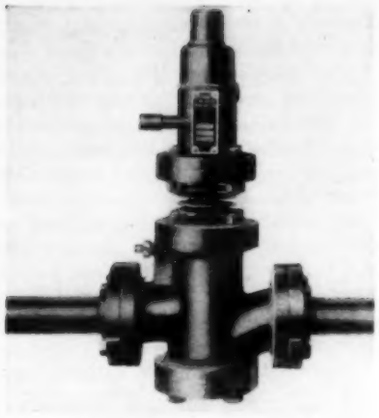
*Construction Industry, Summary for the United States.* Bureau of Census Distribution No. C-151. Statistical analysis of costs, including materials costs.

*Census of Manufactures, 1929, Vol. II. Reports by Industries.* Bureau of the Census; $3.00. An assembly of the industry series of reports, preceded by a general summary.

*State Summaries of Manufactures.* Mimeographed series of 48 documents giving for each state a summary by individual industries, number of establishments, wage earners, etc., from the Census of Manufactures, 1931.

*Analyzing Consumer Markets.* A series of documents giving regional domestic information under the title "An Aid for Analyzing the Market for General Consumer Goods in . . ." Approximately twelve regional pamphlets. Bureau of the Census; 5 cents each.

# NEW EQUIPMENT



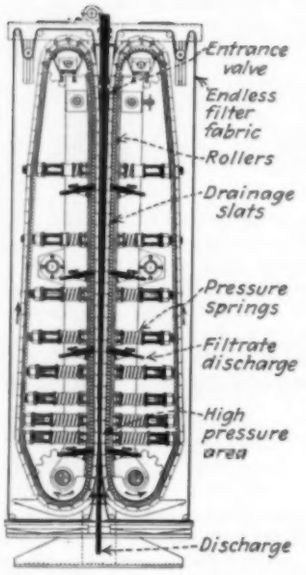
Area-Type flow meter

## Continuous Pressure Filter

For continuous, pressure filtration, in combination with high-pressure pressing of the filter cake, the Thompson Continuous Filter Press Co., 7321 Eighth Ave. South, Seattle, Wash., has recently introduced a vertical machine which is said to produce a clear filtrate and a dry cake without fiber destruction. Mr. Thompson, the inventor, developed this press for use in his own fish byproduct separation business. When it was discovered that the filter was equally applicable for many other purposes, a separate company was formed to manufacture and market it.

The principal parts of the filter are indicated diagrammatically in the accompanying sketch. In brief, it consists of two opposed filter surfaces carried on traveling drainage slats between which the slurry is introduced. In the upper part of the press filtration takes place under hydrostatic pressure. As the cake builds up on the two opposed surfaces, the surfaces are gradually moving downward and toward each other so that in the lower part of the press, a squeezing action, as high as 500 lb. per sq.in. or even higher, is exerted on the cake, forcing out a maximum of liquid. The compacted cake is then discharged from the bottom of the press.

In more detail, it is to be noted that there are two continuous bands of filter fabric which are supported by slats carried on a chain belt and driven by sprockets through a ratchet mechanism designed to give variable speed. Pressure is put upon the slats by a series of coiled springs and the action is made relatively frictionless by the use of a number of independent rollers between the back of the filter slats and the pendant frames. Filtrate is drawn off at a number of points by means of pick-ups located at different elevations. After they leave the press, the filter cloths may be carried through cleaning or washing equipment or treated in any other desired manner, as their length is immaterial.




Thompson pressure filter in section

The filtration and pressure chamber is made tight at the edges by metallic ends. A plug at the top of the chamber through which the slurry is fed serves as the upper closure. The compressed cake in the lower part of the machine supplies the necessary back pressure for filtration.

## Area-Type Flow Meter

For measuring the flow of viscous materials, the Brown Instrument Co., Philadelphia, Pa., has developed what is called the Area-Type flow meter, a device which is installed directly in the pipe line. Since there are no pressure taps nor seals required, as in the case with orifice meters, the new meter is said to be suitable for handling liquids which solidify on cooling. Furthermore, corrosive materials may be metered without the use of special seals.

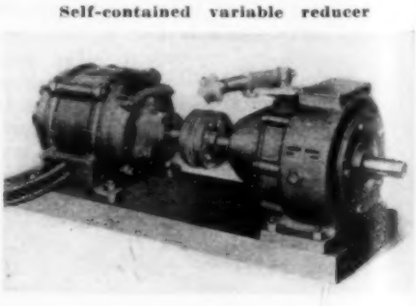
Briefly, the construction of this meter is as follows: In the lower part of the meter body is an offset fluid passage which is partially blocked by a piston. On the amount of the flow depends the degree to which the piston rises to permit the passage of the fluid. The piston is connected to an inductance bridge which transmits the indication electrically to an indicating or recording instrument. The meter employs an evenly graduated scale. Its range may be altered by adding to the weight of the piston or by changing the size of the orifice sleeve.

This company has also introduced what is known as the Brown Compensated Air Cell, a wet-type, nonrechargeable battery intended especially for use with potentiometers. The cell is said to have a life of over 2½ years, to give constant current output, and to require a minimum of attention. When this cell is used, it is stated that the potentiometer will operate at least one month without standardizing. The cell is shipped dry and rendered active by adding cool drinking water.

## Variable Reducer

Infinitely variable speed from zero to 240 r.p.m. (higher if desired) is possible with the new Johnson variable reducer recently developed by the Smith Power Transmission Co., Penton Bldg., Cleveland, Ohio. As appears in the accompanying illustration, the machine is self-contained and direct-connected to its motor. Speed variation is accomplished by changing the eccentricity of a variable-throw crank driving five arms attached to one-way clutches. All mov-

Self-contained variable reducer



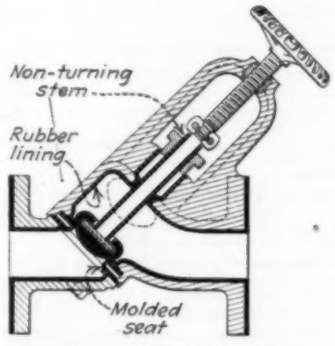
ing parts have anti-friction bearings and operate in a bath of oil. The machine is said to be of high mechanical efficiency and absolutely noiseless in operation.

## Pipe Dope

Technical Products Co., Sharpsburg Station, Pittsburgh, Pa., has announced the addition to its line of acidproof and insulating cements of a pipe dope for making joints tight against gas, air, steam and acid. This compound, known as Sauer-Eisen pipe dope, does not harden or freeze. Consequently, it is stated that joints can easily be dismantled after service. It is also used on bolt threads, gaskets, flanges and valves.

## Vulcalock Valve

Depending on the conditions of service, the new Vulcalock valve developed by B. F. Goodrich Rubber Co., Akron, Ohio, may be lined with any of the standard Goodrich Acidseal rubber compounds, either hard or soft. As appears in the accompanying drawing, the new

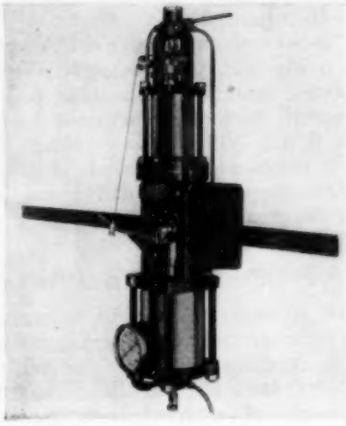



Cross-section of Vulcalock valve

valve differs from earlier practice in a number of particulars. A resilient, rounded disk snaps over a circular plate on the lower end of the stem. The stem does not turn in the stuffing-box. The seat, which consists of a metal-reinforced, molded rubber ring, is reversible, and readily replaced if necessary. On sizes up to and including 6 in. there is no restriction of flow through the seat ring. The valve may readily be demounted by removing bolts which join the two halves of the body in the plane of the seat. By reversing these parts, the valve may be changed from straightway to angle. Such changes or replacements may be made without the use of special tools.

## Combustion Controller

For controlling smaller and medium-sized boiler installations, Morey & Jones, Ltd., 922 South Hemlock St., Los Angeles, Calif., has introduced a new automatic regulator which adjusts the setting of dampers, oil- or gas-firing valves, air-inlet louvres or other equipment to maintain constant steam pressure. Variation in the pressure from the set point causes movement of a pilot valve which admits steam (or water) to a cylinder so as to move a piston. The piston operates a lever which in turn regulates the dampers, valves, etc. A compensator is supplied to prevent over-travel and hunting. The regulator is intended for controlling boilers operating at steam pressure from 3 to 450 lb.



Boiler-pressure regulator

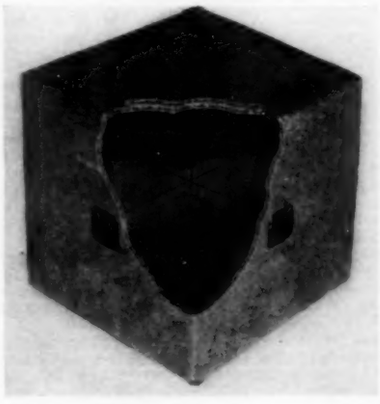
## Chain Flexible Coupling

Link-Belt Co., Indianapolis, Ind., announces the new "RC" flexible coupling which consists of two cut-tooth sprocket wheels joined together by a piece of this company's Silverlink roller chain. The two sprockets serve as the two halves of the coupling and the chain as the flexible coupling medium.

## Bulk Shipment Container

Bulk shipment of chemical powders and crystals, in weights up to 90 lb., is the purpose of a new type of corrugated fiber box recently developed by the Nelson Corp., Standard Oil Bldg., Baltimore, Md. A feature of the new design is the use of wire stays running from the center of each side wall to the center of the opposite wall. These braces are said to prevent bulging and insure maximum strength. The box is supplied knocked-down with wires in place, with or without a paper liner.

Cutaway view of new fiber container

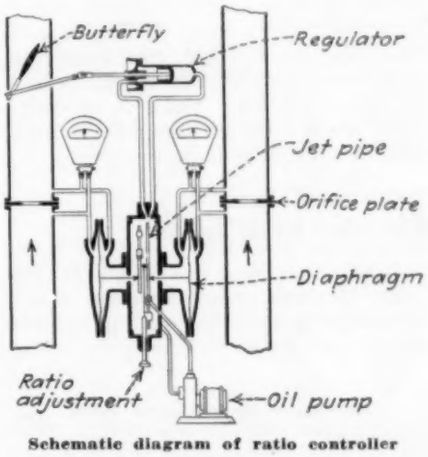


## Flexible Conveyor Belt

Extreme flexibility, minimum stretch and longer belt life are said to be outstanding features of a new conveyor belt introduced under the name of "Condor" by the Manhattan Rubber Mfg. Division, Raybestos-Manhattan, Inc., Passaic, N. J. Performance of the new belt is attributed to a specially woven duck which is used in the carcass, together with a new bonding compound and method of impregnating the belt. After more than five years of test, the manufacturer states that the new belts have surpassed all performance records of older belts on the same installations.

## Ratio Controller

H. A. Brassert & Co., Chicago, Ill., has recently introduced into the United States the Askania Jet-Pipe controller which is indicated diagrammatically in the accompanying sketch. In the set-up shown, it is desired to control the ratio




Schematic diagram of ratio controller

of flow through two pipes. The two pressure differentials are transmitted to the sides of two leather diaphragms which position a pivoted jet pipe. Oil supplied under a pressure of 60 lb. to the jet strikes two small orifice holes connected to the two ends of a regulating piston. The position assumed by the piston depends on the position of the jet with respect to the two orifices. The regulator piston in turn adjusts the butterfly valve in the controlled-fluid line. The ratio may be adjusted by

altering the location of the pivot point through which the motion of the left-hand diaphragm is transmitted to the jet pipe. The position assumed by the latter depends upon the relation between the two differentials and moves so as to maintain a constant flow ratio in the two pipes. This method is said to be very positive in action and to give a speed of regulation readily controlled by the operator.

## Electric Acidity Meter

For the comparative measurement of acid content of solutions and mixtures used in fermentation, pharmaceutical, food, beverage and other processes, the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has developed an outfit known as the "Electrynx" kit. This consists of a sensitive microammeter and a set of six pointed electrodes of dissimilar metals. By choosing the proper pair of electrodes the induced voltage may be kept within the range of the instrument for any type of service.

## Automatic Pump Primer

Pennsylvania Pump & Compressor Co., Easton, Pa., is offering a new automatic priming system that may be applied to any centrifugal pump. This employs a small motor-driven, rotary vacuum pump mounted on the centrifugal pump and arranged to evacuate any air in the casing or suction line. When the pump is started the evacuator runs until the pump is primed, whereupon, the main motor starts and the evacuator stops. Should the pump lose its prime, the main motor is automatically stopped, the vacuum pump started and the cycle of priming repeated.

## Electric Check Valve

What has been designated as the Type M check valve, a device which automatically shuts down the pump if it should lose its water during operation, has recently been announced by Barrett, Haentjens & Co., Hazleton, Pa. This is a combination of a check valve with a Mercoid flow switch, the latter connected into the low-voltage coil of the motor starter and actuated by the valve flap. While flow continues the flap is raised and the switch is closed. If flow ceases, the switch opens and stops the pump.

Automatic electric check valve

## Transparent Cup Goggles

Eye protection is said to be encouraged by a new design of transparent-cup goggle recently introduced by Willson Products, Inc., Reading Pa. The cups are made of a transparent material permitting the wearer to perceive objects through them. The result is to eliminate the "blinder" effect. The goggles are said to be well ventilated and light in weight and, as is shown in the accompanying illustration, capable of being worn over glasses.

New transparent-cup goggle

## MANUFACTURER'S LATEST PUBLICATIONS

**Air Conditioning.** Niagara Blower Co., Buffalo, N. Y.—Extensive loose-leaf catalog of air conditioning equipment made by this company, including fan coolers and heaters, humidifying heaters, and aluminum cooling and heating sections.

**Alundum.** The Norton Co., Worcester, Mass.—Leaflet describing the use of Norton porous mediums in activated sludge plants; also folder on rubber-bonded alundum safety treads for stairways.

**Belting.** E. F. Houghton & Co., 240 West Somerset St., Philadelphia, Pa.—Wall chart giving information on the calculation, installation and care of leather-belt drives.

**Centrifugals.** American Tool & Machine Co., 1415 Hyde Park Ave., Boston, Mass.—8 pages on suspended centrifugals made by this company.

**Chemicals.** Eastman Kodak Co., Rochester, N. Y.—April, 1933 catalog and price list of organic chemicals made by this company.

**Chemicals.** Hercules Powder Co., Wilmington, Del.—Series of folders describing the properties of Yarmor steam-distilled pine oil.

**Coatings.** Semet-Solvay Co., 61 Broadway, New York City—11 pages summarizing in simple manner suitable protective paints for many uses.

**Compressors.** Allis-Chalmers Mfg. Co., Milwaukee, Wis.—Leaflet 2159—4 pages on a single-stage, water-cooled rotary air compressor and dry-vacuum pump made by this company.

**Electrical Equipment.** General Electric Co., Schenectady, N. Y.—Publications as follows: GEA-1695, Quiet induction motors; GEA-1714, Sound-isolating motor bases; GEA-1716, Motors and control for hazardous locations; GEA-1728A, Tellurium-compounded, all-rubber-jacketed portable cable.

**Equipment.** Allis-Chalmers Mfg. Co., Milwaukee, Wis.—Bulletin 149—12 pages on equipment for breweries including power generation and transmission, compressors, drives, malt mills and handling equipment.

**Equipment.** J. P. Devine Mfg. Co., Mt. Vernon, Ill.—24 pages illustrating this company's shop facilities and showing a number of installations of its oil-refining equipment.

**Equipment.** Roots-Connersville-Wilbraham, Connersville, Ind.—Leaflet 21-B-24—Describes the use of positive rotary blowers for moving liquids by air pressure.

**Feeders.** Traylor Vibrator Co., 1400 Delgany St., Denver, Colo.—Bulletins C-106 and 107—Illustrating and describing laboratory and industrial vibrating conveyors and feeders made by this company.

**Gas Masks.** Mine Safety Appliances Co., Pittsburgh, Pa.—Bulletin EE-1—4 pages describing ammonia masks made by this company.

**Instruments.** American Meter Co., 105 West 40th St., New York City—Catalog EG-2—16-page booklet describing the Westcott orifice meter made by this company. Also describes an improved integrator which totalizes while automatically taking account of pressure variations.

**Instruments.** The Bristol Co., Waterbury, Conn.—Bulletin 390—40-page general bulletin showing briefly this company's instruments for pressure, vacuum, liquid level, temperature, humidity, electricity, time cycle, and operation recording and control.

**Instruments.** Builders Iron Foundry, Providence, R. I.—Bulletin 266—8-page booklet describing this company's Chronoflo electric fluid meter for recording at a distance.

**Instruments.** The Foxboro Co., Foxboro, Mass.—Folder describing the improved potentiometer pyrometer controller recently offered by this company.

**Instruments.** The Foxboro Co., Foxboro, Mass.—Bulletin 184—8 pages on this company's electric-contact controllers for temperature, pressure, humidity and level.

**Instruments.** Littelfuse Laboratories, 1772 Wilson Ave., Chicago, Ill.—Catalog 5—8 pages on fuses for protection of instruments from 1/100th to 2 amp. capacity.

**Tubing.** Steel & Tubes, Inc., Cleveland, Ohio—Form 218-B—67-page handbook on electric welded tubing, describing manufacture, tests, specifications and uses.

**Valves.** Edward Valve & Mfg. Co., East Chicago, Ind.—Leaflet briefly describing typical valves made by this company.

**Water Gas.** Semet-Solvay Engineering Corp., 40 Rector St., New York City—Booklet and model illustrating the new Semet-Solvay process for carbureting with heavy oil by use of the "Ignition Arch."

**Water Treatment.** The Hagan Corp., Pittsburgh, Pa.—"A Clean Boiler Story," 20 pages attractively setting forth the application and advantages of the Hall process of boiler-water treatment.

**Welding.** American Murex Corp., 120 Broadway, New York City—Bulletin describing this company's new straight-gap method of welding for producing butt welds in plate without the necessity for bevelling.

**Welding.** Smith Welding Equipment Corp., Minneapolis, Minn., and Smith Welding Equipment Eastern Corp., Roslyn, Pa.—Catalog E-106—56-page general catalog on welding and cutting equipment and accessories.

**Welding.** Republic Steel Corp., Massillon, Ohio—17-page book completely describing with illustrations and photomicrographs, the welding of Enduro stainless alloys.

**Winders.** Cameron Machine Co., 61 Poplar St., Brooklyn, N. Y.—Booklet illustrating a number of mill-type roll winders for use in paper and board mills.

# NEWS OF THE INDUSTRY

**Largest annual meeting on record of Manufacturing Chemists' Association on June 1 concentrated attention on provisions in the national industrial recovery bill. Drug trade and other manufacturing lines take steps toward industry control in support of the recovery program. Midwest Power Show scheduled for Engineering Week at Chicago**

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## Midwest Power Show During Engineering Week

TO PERMIT the maximum attendance, the sixth Midwest Power Show is to be held in Chicago during Engineering Week, June 25 to July 1, 1933, instead of in February as formerly. Preliminary estimates indicate the complete utilization of the 85,000 sq.ft. of floor space in the Coliseum Building. In addition to steam generating equipment, exhibits will include power-operated tools, generators, motors, engines, pumps, heating and air conditioning apparatus. Educational features of the Show will be sponsored by the Armour Institute of Technology. Admission will be by invitation which is being offered by the various companies exhibiting.

## Newark College Establishes Gilbreth Room

AT the Newark College of Engineering a room, known as the Gilbreth Room, has been dedicated to the memory of the late Frank B. Gilbreth. This room now contains some of his papers, pictures, and instruments, and a library of works on scientific management and human relations. The college would be glad to acquire copies of the following books written by Mr. Gilbreth: Field System; Concrete System; Bricklaying System; Motion Study Primer of Scientific Management; Time Study, the Science of Obtaining Methods of Least Waste.

## Drug Institute Formed to Supervise the Industry

THE Drug Institute of America, Inc., has been formed to unite all branches of the drug industry in an effort to end destructive competition and to pay fair wages, the association being formed in support of President Roosevelt's recovery program.

The announcement of the formation of the Drug Institute stated it will be patterned along the lines of the American Iron and Steel Institute and the American Petroleum Institute, which have been functioning for several years. Members of the Drug Institute will be pledged to co-operate with each other and with the government for the common good.

The association will endeavor to observe a high standard in its products, to control output, maintain fair wages and fair profits, eliminate unfair competition and price cutting and also to exercise general supervision of the industry as a partnership in planning.

Wheeler Sammons, formerly president of the Associated Stores Company and former president of the A. W. Shaw Co. and former vice-president of the McGraw-Hill Co., has been elected acting managing director.

## The Koppers Co. Awarded the Wetherill Medal

THE Franklin Institute of Philadelphia, on May 17, conferred a John Price Wetherill Medal on The Koppers Co., of Pittsburgh, "in consideration of the development of systems for the liquid purification of gases; the success of which is evidenced by the number of such installations in regular use."

Practically all manufactured gas, contains hydrogen sulphide. The usual method of purification, by the use of iron oxide in steel or concrete boxes through which the gases are passed and the sulphur removed by combination with iron, involved large ground area, expensive structures, the necessity for frequent changes of the oxide and arduous labor.

The Koppers Research Department, working at the Mellon Institute and at The Koppers Co.'s plants, developed a purification process using a liquid absorber. In this process the hydrogen sulphide is first absorbed, then removed from the absorbing solution by actification with air. This air, containing the hydrogen sulphide, is either discharged into the atmosphere or utilized through combustion in boilers, gas producers, or coke ovens. The original experiments having been made at the plant of the Seaboard By-Product Coke Co., a subsidiary organization and the original plant having been built on its property, the process received the name "Seaboard Process."

Up to January 1, 1932, The Koppers Co. had installed sixty-seven plants in America, with a purifying capacity of 533,000,000 cu. ft. of gas per day. Plants in Canada, France, Germany and Japan had a daily capacity at that time of 84,000,000 cu. ft.

## The Texas Co. Enters Suit on Oil Cracking Patents

SUIT alleging infringement of cracking patents has been brought by The Texas Co. against Star Refining & Producing Co. In this suit, The Texas Co. alleges infringement of the patent to Behimer No. 1,840,012, for Apparatus for Making Gasoline, and patent to Behimer No. 1,883,850, for Process for Making Gasoline. The operations complained of are the cracking operations conducted by the defendant at its plant at Fort Worth, Texas. The suit was filed at Fort Worth.

# NEWS FROM ABOARD

*By Special Correspondents of Chem. & Met. at Berlin and Paris*

## Berlin

AT A meeting called by Prof. Ubbelohde and attended by representatives from government, scientific and technical institutions, and industry the German Society for Petroleum Research was founded on May 9. Progress in this field is to be promoted by carefully planned collaboration and by technical and economic research. A primary object is the establishment of a domestic refining industry, as outlined by Prof. Ubbelohde in a paper presented to the Department of Commerce, in which was stressed the need of a German oil-refining industry, similar to that established in France. Arguments were not lacking on the part of the coal and lignite producers who maintained that Germany should look for her mineral oil requirements to the already known deposits of coal and lignite, from which may be produced tar oils, benzol, and gasolines; the fact must also be considered that this industry already employs 100,000 men, whereas only comparatively few may look for employment in the refineries. These arguments have, however, been of no avail as the present exceptionally low price on foreign crudes gives promise of great profits for domestic refineries.

The asphalt industry is looking to the future with much hope in view of the government's extensive paving program; increased sales are also expected in the roofing field with the improved agricultural condition.

In the utilization of coke-oven tars, means are sought to eliminate the variations in the stocks of pitch and oil which result from the fluctuating demands for briquets and fuel oil. According to the opinion of the noted expert in this field, Dr. Broche, the following possibilities should be considered: production of oils of high viscosity from the higher-boiling tar tractions. (1) catalytic hydrogenation of tar oils with boiling point above 200 deg. C., using an initial hydrogen pressure below 100 atm. and removing the asphaltic material gives a 53 per cent recovery of good oils. (2) such oils which have a strong tendency to form asphalt and which therefore cannot be used as lubricating oils are blown with hot air whereby the pitch recovery is materially increased. (3) heavy tar oils which do not command sufficient price as fuel oils are converted into motor fuel by the following method: after incomplete combustion these acids are converted into hydrocarbons. Theoretically 100 kg. napthalene gives 61 kg. benzene, with phthalic acid as an intermediate product; naphthalene vapor or gasified tar oil mixed with air, at 400-500 deg. C. is passed over pumice treated with vanadium pentoxide catalyst, and the resulting phthalic acid product is treated with lime. As the yield is about 49 per cent, 204 kg. naphthalene, present market value about 9 RM., is required for the production of 100 kg. benzene, with a value of 24 RM. (4) coal tar oils do not compare favorably with gas oil made from crude oil or even from lignite tar as diesel engine fuel. To make competition possible they must be treated with oxidation catalysts, among which vanadium pentoxide has been found particularly effective on a large scale. (5) lowering of the flash point of the coal tar oils when used in diesel engines is made possible by placing, opposite to the fuel nozzle, an object of steel equipped with good heat insulation. Diesel engines equipped with such contacts of stainless steel may operate on tar oil as well as gas oil.

Another method of utilizing coal tar oils is suggested by Dipl. Ing. Steinle, Verkaufsvereinigung für Teererzeugnisse, Essen, (Tar Products Sales Association), who advocates their use in central heating plants in institutions and office buildings. Satisfactory burner types have been developed, with electric ignition of the atomized oil, completely automatic in operation and free from smoke and soot. One liter coal tar oil produces 9,300 kg.cal., compared with 3,500 for one liter of coke; considering the higher efficiency of the oil, 80-90 per cent, compared with 50 per cent for continuously burned coke, the figures are 8,400 and 1,750 kg.cal., respectively. Based on thorough tests oil-firing may be used economically when the price ratio of oil to coke is 3:1.

Deutsche Gasglühlicht-Auer-Gesellschaft has developed a new filter for treatment of exhaust gas from power engines (German Patent 564,265). The objectionable resistance occurring in filters of this type has been overcome by the simple method of using several individual filters in parallel.

A new rosinous ester is being produced by heating colophon for a long period of time at 200 deg. C. with a mixture of commercial stearin and palmitin alcohol, now obtained by hydrogenation of stearic acid. Dipl. Ing. Fritz thus obtained a rosinous compound which is first liquid and which later solidifies to a fatty substance possessing neither the odor nor the sticky property of colophon or the fatty alcohol. This rosinous ester is used for belt dressing, shoe polish, and rust proofing; it may also find application as a softening agent for nitrocellulose or in the manufacture of artificial leather.

## Paris

THE general situation in the chemical industry is, however, quite satisfactory, or at least less serious than might be expected, and an improvement may be looked for if confidence were restored and if the foreign situation were less troubled. The essential point is, that whereas domestic sales are, to a large extent at least, profitable, export business is faced with great difficulties. This is partly a result of the high cost of production, caused by excessive taxation, and partly due to the inflation of the British and the American currencies, factors which certainly are going to cause further decline in exports.

A noticeable reduction in imports is also felt in certain fields, as a result of import restrictions enacted to protect domestic producers from competition. As a result of this reduction several new domestic industries have been started, particularly in the field of nitrogen fixation. Thus the imports of ammonium sulphate, which in 1931 was 22,700 tons, fell to 5,000 tons in 1932; imports of Chilean nitrate, in 1931, 375,000 tons, valued at 405,000,000 fr., was 305,000 tons, or 280,000,000 fr. in 1932. Altogether chemical imports have fallen from 1,900,000,000 fr. in 1929 to 960,000,000 fr. in 1932. Certain products have not been affected, such as pharmaceuticals and mineral pigments, both of which have remained at about 50,000,000 fr.; photo-chemical products, at 60,000,000 fr.; phosphate fertilizers, with 40,000,000 fr. have even shown a slight gain.

Considering the imports from the various countries it is interesting to note that Germany's share, 28 per cent of the total in 1928, fell to 21 per cent in 1931, whereas imports from the United States advanced from 3.8 per cent in 1925 to 8 per cent in 1932; further increase may result from the results of the Franco-American conference.

The single disquieting feature in the economic picture is the low prices on agricultural products, at the time when prices on industrial products have a rising tendency.

# Record Attendance at Manufacturing Chemists' Annual Meeting

CHEMICAL executives assembled at Shawnee-on-the-Delaware, June 1 and 2 for the largest annual meeting of the Manufacturing Chemists' Association, unanimously resolved that the National Industrial Recovery bill, as it was then drawn, was unsound in important respects and if enacted would fail to attain the objectives sought unless substantially amended. At the conclusion of the meeting these views were telegraphed to the President, the members of the Senate and the administration leaders who have sponsored this measure in Congress. However, blanket authority was extended to the Executive Committee to take whatever action seemed necessary and desirable in the event that the bill became a law. The Washington office has since had an active part in representing the viewpoint of chemical industry in the various meetings and negotiations being held with the governmental authorities.

This action on the part of the Association followed extended discussion lead by the Association's newly elected president, William B. Bell, president of the American Cyanamid Co., who clearly and forcibly outlined the objectionable features in the proposed legislation. He was followed by Elon H. Hooker, president of the Hooker Electrochemical Co. and by Judge James A. Emery, general counsel of the National Association of Manufacturers.

The work of the Manufacturing Chemists' Association during the year was well summarized in the report of the Executive Committee presented by its chairman, Charles Belknap, president of the Merrimac Chemical Co. He spoke of the unusual activity and gratifying accomplishments directly attributable to the work of the Washington office, where consideration was given not only to the problems immediately concerning chemical industry but also to fundamental economic and financial problems having a far-reaching effect on business conditions in other fields. The work of the Technical Committees was commended, particularly in relation to the development of new containers and the activity of the traffic committee in representing the combined viewpoint of chemical industry in its appearance before the Interstate Commerce Commission.

The dominating importance of domestic business as contrasted with foreign, was emphasized by Elon H. Hooker, in a stirring address on "Internationalism vs. Nationalism." He stated that of the less than ten per cent of total business in American industry which is concerned with imports and exports, about three-fourths is in the hands of five or six great corporations. "What they must lose for the better interest of the whole country, they can afford to lose from present market without disaster, and perhaps can make it up or even increase their business in the intensified domestic market." Mr. Hooker concluded his paper with the outline of a program for desirable legislation affecting banking, agriculture, transportation, unemployment and public works.

Harry M. Mabey, traffic manager of the Mathieson Alkali Works presented a paper entitled "A Changing Transportation Machine and Its Relation to the Chemical Industry." He stressed the need for united opinion in chemical industry with respect to the coordination of all of the transportation facilities of the country. Chemical industry is interested in stability of rates and these, he maintained, are unfavorably affected at present by the unregulated agencies utilizing the highway and waterways service.

**Secretary Watson and newly elected President Bell of Manufacturing Chemists' Association**

Ernest T. Trigg of John Lucas & Co. discussed important trends in the insecticide industry. The most serious technical problem before the industry at present, is the necessity for finding new products non-toxic to human beings but effective in food preservation and crop protection.

At the union banquet with the Synthetic Organic Chemical Manufacturers' Association, Dr. David Friday, Professor of Economics at the University of Michigan, spoke of "Business Revival and the Future of Prices." He said that the last two months have seen the most rapid rise in productive activity in the history of the United States. The volume index of the Federal Reserve is up from 60 in March to 67 in April, with the preliminary figure of 76 for May.

Dr. Friday predicted the continuing rise of prices for the next fifteen months, provided no drastic monetary inflation is effected. The long-time trend of prices, in his estimation, is also upward.

New officers elected by the association are as follows: President, William B. Bell, president, American Cyanamid Co.; First Vice President, E. M. Allen, president, Mathieson Alkali Works; Second Vice President, George W. Merck, president of Merck & Co.; Treasurer, J. W. McLaughlin, vice president of the Carbide & Carbon Chemicals Corp. of New York; Secretary, Warren N. Watson, Washington, D. C.

Members of the executive committee are as follows: Charles Belknap, president of the Merrimac Chemical Co., chairman; Charles W. Millard, General Chemical Co.; H. L. Derby, American Cyanamid & Chemical Corp.; Leonard T. Beale, Pennsylvania Salt Mfg. Co.; J. H. Dunbar, Grasselli Chemical Co.; Ernest T. Trigg, John Lucas & Co.; Clyde D. Marlatt of the Martin Dennis Co., Newark, N. J., who was elected to succeed George W. Merck.

## CALENDAR

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, spring meeting, Chicago, Ill., June 14-16.

AMERICAN SOCIETY FOR TESTING MATERIALS, Chicago, Ill., June 26-30, 1933.

ELECTROCHEMICAL SOCIETY, fall meeting, Chicago, Ill., Sept. 7, 8, 9.

AMERICAN CHEMICAL SOCIETY, 86th meeting, Chicago, Ill., week of Sept. 11, 1933.

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY, fall meeting, Appleton, Wisc., Sept. 26-28.

NATIONAL METAL CONGRESS AND EXPOSITION, Detroit, Mich., Oct. 2-6, 1933.

AMERICAN PETROLEUM INSTITUTE, Chicago, Ill., Oct. 24-26.

FOURTEENTH EXPOSITION OF CHEMICAL INDUSTRIES, New York, week of Dec. 4-9, 1933.

## NEWS FROM WASHINGTON

By PAUL WOOTON
*Washington Correspondent of Chem. & Met.*

DOGGING the footsteps of the administration is the fear that unless the buying power of a vast number of people can be raised within a few months, the country is headed deeper into depression. The objective of the administration's program is to put men back to work at their normal jobs by shortening the work week, increasing wages, and stemming a rise in prices as long as possible. If prices rise as fast as wages little good will be accomplished.

According to Gen. Hugh Johnson's industry set-up all authority and complete responsibility will be vested in the administrator. An administrative board is not desirable because there is no responsibility in voting control. A board will be appointed to coordinate and use all appropriate existing agencies of the government in order to prevent confusion. Under the administrator there will be staff departments that will plan and devise but will not execute.

No action will be taken without consulting the representatives of industry and labor. On one hand of the administrator there will be a labor advisory board selected by Secretary Perkins and, on the other, an industrial advisory board appointed by Secretary Roper to immolate the administrator from any criticism of partiality.

Exhortation, persuasion and negotiation will be used to bring all industries into the program. The licensing authority will not be used to drag them in. This will be reserved for the "chiseling fringe" to protect the businesses that bind themselves by the codes of fair competition, and the labor that they employ.

All industrial and trade organizations that submit plans must include representation of any minority and any outsiders. The function of the administrator will be that of an arbiter.

In order to prevent importers from defeating the purpose of the bill, imported products will be subject to embargo on complaint that their importation is detrimental to any industry operating under a code and results in unfair methods of competition. It is expected that this drastic authority will enable the administrator to set up much the same sort of control over import trade as over domestic industry without resorting to actual embargo.

The Government $3.3 billion public works program is regarded as a stimulant that will help to carry the program along until industrial activity takes hold. The whole field of possible projects is now being raked for those that can be put under way immediately. The purpose is to undertake construction that by October 1 will represent an expenditure at the rate of $1 billion a year. Estimates picked out of the air put 1,000,000 men to work on public works inside of a year; 3,000,000 men back in industry.

## EDITORIAL INTERPRETATION OF THE

### Petroleum

Because the Big Bill, as the industrial recovery measure is called in Washington, is admittedly not broad enough to cover the petroleum industry, an amendment was adopted which authorizes the President to prohibit interstate shipment of oil produced in violation of state laws. This provision was entirely acceptable to the Independent Petroleum Association Opposed to Monopoly, which wants no specific regulation of either the production or the price of crude; but it was a great disappointment to the regular independents, represented by the Independent Petroleum Association of America, which had staked its hopes for stabilizing the operations of the industry on the Marland bill. This bill was ditched by the President when opposition from the rump organization of independents, representing California and Texas factions, threatened to block the whole industry bill. The President proposed as a substitute a short amendment which would have given him broad discretionary power over the production and marketing of petroleum, but this was rejected by the Senate Finance Committee. The practical extent of the Federal Government's control over the oil industry will be limited, therefore, to support in the enforcement of state laws. The President's authority under the industry bill, as interpreted by the Attorney General, is not broad enough to require either control or allocation of crude production.

### Muscle Shoals

Tennessee Valley Authority, now a Federal agency under the Norris Muscle Shoals bill, is to be headed by three directors. The chairman is Dr. Arthur E. Morgan, president of Antioch College, an engineer of wide experience in reclamation, flood control, and related civil engineering practice. One of his colleagues will be Harcourt A. Morgan, a biologist with experience in entomology, zoology, and state experiment work. At the time of appointment he was president of the University of Tennessee, thoroughly acquainted with the agricultural problems of the area to be served. The third member of the board is to be David E. Lilienthal, a lawyer well known for work on public utilities, and for five years past a member of the Wisconsin Public Utilities Commission.

The Authority will face three major groups of problems. The development of and disposal of power on the Tennessee River comes first through the existence of the Wilson Dam, with large surplus available for immediate sale. States and municipalities are to have priority, but there is no reason to believe that they will take all the energy which can be supplied. Industrial customers will, therefore, presumably be sought soon.

The Authority's responsibility with respect to fertilizer does not compel, but does permit, fertilizer manufacture. The Fixed Nitrogen Research Laboratory will come under its jurisdiction. This means research, not alone on production and preparation methods, but also on fertilizer utilization. Agronomy may prove more important than chemical engineering.

Reclaiming of marginal or submarginal farm land presumes reforestation. This suggests pulpwood developments and a paper and pulp industry for the territory. Certain agricultural specialists in Washington state this prospect is materially more promising than any industrialization of the mineral resources available in the Valley.

### Food and Drug Act

A draft of the new Food and Drug Act was formulated early in June by the Department of Agriculture. This was to be introduced in Congress, but will not

Chemical process industry will probably find it essential to follow the same pattern. This will mean the inclusion in the master control group of representative of all types of chemicals and of all major corporate and trade divisions. Functioning from raw material purchased through to ultimate merchandising would be a vital requirement of an acceptable control committee.

Under such an organization, which may well function through Manufacturing Chemists Association, can be as many subsidiary commodity committees, even regional committees, as may seem necessary. But all of these must coordinate in order to function in contact with the Government through a common central body. General Johnson's object in seeking this procedure is evident. He realizes that separate contact with thousands of technical, trade, or regional bodies would be impossible. He is convinced that the maximum of industry self-regulation can be accomplished by such coordinated functioning.

Manufacturing Chemists Association is perfecting plans for its general program. Under the major control committee will be subcommittees caring for major groups of chemicals. In keeping with the spirit of the bill non-members of the association will be expected to participate.

Commodities to be controlled in detail and rules required have not yet been selected by M.C.A. It is recognized, however, that the chemical industry will have a simpler code than many other groups because retail merchandising is not involved.

Licensing of corporations is a permissive, not a compulsory feature of the act. If the leadership in the chemical industry can establish effective control, that result will be welcomed by the Government administrator who is not desirous of using his police power.

Every industry must consider the problems of its relationship to labor as the bill is directed as much to the welfare of labor as it is to the recovery of industry. Apprehension of industrial executives on this score seems largely founded on the active participation in the administrator's office of Donald Richberg, prominent labor lawyer. His presence implies that labor will insist upon provisions which some believe constitute a charter to organized labor to force the unionization of all industry. General Johnson declares that he will not permit the law to be made such a vehicle for the labor organizer.

It must not be forgotten that protection of labor offered by the bill was as essential to its enactment as was the exemption of industry from the full impact of the anti-trust laws. Secretary Perkins remarks in this connection that "as the bill permits close integration of industrial managements it is unthinkable that it would not provide equivalent opportunity to wage earners for their self-protection in every lawful and orderly way."

Many of the process industries will not, of course, work through Manufacturing Chemists Association. Leather, paper, rubber, and the other major groups will find analogous problems in their respective fields.

Many distorted concepts of industry control have arisen. And all sorts of new groups apparently are seeking preferred places in the new conveyance, desiring to ride past anti-trust barriers conveniently. They receive small encouragement in Washington. Obligations to public and Government are a prerequisite to securing such privileges. Stable, long organized agencies are preferred as a nucleus wherever available.

# ADMINISTRATION'S RECOVERY PROGRAM

receive legislative action at this session. It was put forward for discussion in interested industries in advance of hearings that presumably will be held during early 1934.

This bill, the major provisions of which were indicated in last month's issue of *Chem. & Met.*, if enacted as proposed, will completely replace the existing law. It is not merely a set of amendments thereto. Many chemicals manufacturers whose products are used in connection with foods, drugs, cosmetics (to be covered by the law) and related commodities are invited by the Administration to give the proposed legislation careful study during the coming months.

### Public Works

The Federal public-works program is a vital part of the plan for immediate stimulation of employment. It may also be used as an aid in bringing industry into line under the Control Bill. In some cases public works contracts for such industry will be the best available bait.

The financing of public works will be by new security issues. The interest and amortization fund for the $3,300,000,000 needed is to be provided from special taxes which were one of the principal causes of controversy throughout the entire legislative history of the bill. This tax controversy is quite independent of the one involved in veterans compensation and the balanced operating budget over which Congress and the President also have disputed.

Farm relief measures under Secretary of Agriculture Wallace are nominally independent of industry regulations. However, certain process industries fall within the definition of both agricultural and industry control acts. Hence such industries may find themselves riding two horses, unless a triangular agreement is reached between the industry, Secretary Wallace, and Industry Administrator Johnson.

The two acts are in many respects alike, are identical in purpose, but at least at the start are being handled in quite different administrative fashions. The Agricultural Adjustment Administration is, for example, dealing with regional groups and small units in industry according to procedures strikingly different than those sought by General Johnson.

It is anticipated that such groups as the sugar refining industry, though nominally under both bills, will be cared for through the agricultural administration. Other secondary farm products like leather may, on the other hand, be supervised by the industry administrator, though they may in some particulars come under Secretary Wallace's influence. Adjustment of such conflicts will be made from time to time as specific need arises.

### Join Now!

The industrial control program is appalling in its magnitude and novelty. No one can now foretell the degree of success attainable. It may be a complete failure. But America is committed to this vast economic and social experiment.

Chemical industry has no choice but to participate. Organization is essential. Substantially unanimous participation and cooperation are presumed by the law. Manufacturing Chemists Association appears to be the logical agency to represent chemical manufacturers. Other process industry groups will find the need for analogous leadership.

Every company not already a member of a trade association competent to lead its industry should join now.

EDITOR.

# NAMES IN THE NEWS

FRANK CORTESE, formerly research assistant in the Rockefeller Institute, has taken a temporary postion with A. E. Marshall, consulting chemical engineer of New York City.

F. B. LA FORGE and H. L. J. HALLER of the Department of Agriculture have received the Hillebrand prize of the Chemical Society of Washington, D. C. The award was made for their discovery of the chemical structure of rotenone, a new and powerful insecticide.

GEORGE MCCARTEN, former project engineer for the General Chemical Co., has joined the development department of the Calco Chemical Co., at Bound Brook, N. J.

J. C. WHITE, general superintendent, has been elected vice-president and general manager of the Tennessee-Eastman Corp. Herbert G. Stone, who has been plant superintendent, has been made general superintendent.

C. V. HOLLAND, formerly chemical engineer for the Virginia-Carolina Chemical Corp., has joined the Sulco Laboratories, Inc., of New York City.

JOHN R. SHEFFIELD, for many years connected with The Dorr Co., is now associated with the Phosphate Recovery Corp. of New York, a subsidiary of International Agricultural Chemical Corp.

CLAUDE E. BRIGHAM has succeeded Mjr. Gen H. L. Gilchrist as chief of the Chemical Warfare Service. Col. Brigham has been appointed for a term of four years. He entered this branch of the service in 1921 and since 1929 he has been commanding officer at Edgewood Arsenal.

CHESTER A. FULTON, president of the Southern Phosphate Corp., who was appointed director of sales for the Davison Chemical Co. last December, has resigned from the latter position but continues as chief executive of the phosphate company.

M. R. BHAGWAT has been appointed secretary of the Committee on Unemployment and Relief for Chemists and Chemical Engineers of New York City. He has been actively engaged in the relief work of the committee since its inception.

COLIN G. FINK

COLIN G. FINK has been awarded the Edward Goodrich Acheson Medal and prize by the Electrochemical Society. The presentation will be made during the fall meeting of the society in Chicago. Dr. Fink, who heads the department of electrochemistry at Columbia University, has a long and distinguished record as an original investigator, an inventor, a teacher, and an officer of the society.

ADAM M. STEEVER has joined the Lindberg Steel Treating Co. as vice-president in charge of technical operations.

ANTON L. NIELSEN, formerly superintendent of the Mohawk Valley Paper Mills, at Little Falls, has joined the Frost-White Paper Mills at Salisbury Mills, N. Y.

H. H. Moss has been awarded the Samuel Wylie Miller Medal by the American Welding Society "for his achievement in the application of fusion welding and oxy-acetylene flame cutting."

C. L. BUTLER has been appointed senior fellow in pure research in the department of research in pure chemistry at Mellon Institute. Dr. Butler graduated from the Pennsylvania State College and the University of Illinois. He continued his studies in the laboratory of organic chemistry of the College de France in Paris. Since 1929 he has held the post of lecturer in the department of chemistry of the University of Pittsburgh in addition to a position in the Mellon Institute.

J. S. HICKS, formerly connected with Sherwin Williams, where he was engaged in research work on paints and lacquers, has joined the consulting firm of Cromell & Murray, Inc., Cleveland. He is in charge of the organic division of the business.

JOHN P. HARRIS, manager of the Chicago office of the Industrial Chemical Sales Co., has been elected president of the American Oil Chemists' Society. He succeeded N. C. Hammer of Dallas, Texas.

HENRY C. SHERMAN, head of the chemistry department of Columbia University, has been presented with the medal of the American Institute of Chemistry.

AXTELL J. BYLES has been elected president of the American Petroleum Institute. Upon his election as president of the Institute he severed his connection with the Tide Water Associated Oil Co., of which he was president, also the Tide Water Oil Co., and the Associated Oil Co.

CHARLES J. BRAND, secretary of the National Fertilizer Association, has accepted the position of coadministrator of the Agricultural Adjustment Administration, with the understanding that he will give only general supervision to the association's work during the period.

E. A. RYKENBOER has been appointed general manager of the R. & H. Chemicals department of the du Pont company to succeed C. K. Davis, who has been elected president of Remington Arms Co.; and Milton Kutz has been appointed assistant general manager of the department to succeed Dr. Rykenboer.

HENRY HOWARD, consulting chemical engineer, has been elected a director of the United States Chamber of Commerce.

JAMES A. VAIL, secretary and chemical director of the Philadelphia Quartz Co. left May 3 for a business trip to Germany to be gone about a month.

F. L. KALLAM, formerly chief engineer of the gasoline department of the Foster Wheeler Corp., is president of Industrial Engineers, Los Angeles, Calif. G. H. Lifur is secretary and treasurer of this corporation and president of the California Forest Products Co. The Industrial Engineers was formed to render consulting services.

W. W. WINSHIP, manager of Thermal Syndicate, Ltd., Brooklyn, N. Y., sailed from Montreal on May 12 for a six-weeks business trip in England.

# OBITUARY

E. F. DANIEL, JR., manager of the Baltimore office of the American Agriculture Chemical Co., died at Union Memorial Hospital in Baltimore on May 16, following an attack of pneumonia.

JOHN J. HOGLEN died on May 11 the result of a severe heart attack. At the time of his death he was sales manager of Hopkins Fertilizer Co. of New Albany, Ind.

GEORGE V. HORGAN, general manager of the National Paint, Oil and Varnish Association and the American Paint and Varnish Manufacturers Association, died on May 25 in Washington, D. C. Complications arising from a general weakness of his system were the cause of his death.

L. J. W. JONES, chief chemist for the Grant Smelter, died in Tacoma, Wash., on May 14. He was 73 years old.

MATHEW H. SLOAN, a retired glass manufacturer, formerly with the Sloan Brothers Co., of Cumberland, Md., died on May 19. He was 72 years old.

LLOYD BALDERSTON died in Wilmington, Del., June 1 at the age of 70 years. Since 1921, he had been engaged in the industrial chemical field.

LUTHER S. JOHNSON died at Del Ray Beach, Fla., on April 12. He had been wintering in the South in an effort to regain his health. Mr. Johnson had been superintendent of the Falls Rubber Co. for several years. Previously he had been connected with the Mason Tire Co., the Firestone Tire & Rubber Co., and the Lee Tire & Rubber Co.

MINER M. AUSTIN, research chemist and metallurgist for the Fansteel Products Co. of North Chicago, Ill., died of pneumonia at his home in Highland Park on March 10. Dr. Austin was born at Portland, Wisc., in 1892 and attended Lawrence College and the University of Illinois. After two years work in the research laboratory of the National Malleable Casting Co., he returned to the Illinois institution and for four years had charge of courses in metallurgy. In 1924 he became associated with the Fansteel organization.

THOMAS J. KEENAN, retired, was found dead on May 1 in his home at South Orange, N. J. Death was due to pneumonia and heart trouble. Mr. Keenan was born in Dundee, Scotland, and was educated as a pharmaceutical chemist. After graduating, he came to this country and served on the editorial staffs of the *Pharmaceutical Record, American Druggist, Pulp,* and *Paper Industry.* When the Technical Association of the Pulp and Paper Industry was formed in 1915 Mr. Keenan became the first secretary. He was very active in establishing the association on a firm foundation in its early days.

H. GREGG SMITH, associate in biochemistry at the State University of Iowa, died Feb. 26, of pneumonia. He was 34 years of age.

Dr. Smith was born in western Ohio, and was educated at the University of Indiana and the University of Rochester. He had been at the Iowa Institution since 1927 where his teaching responsibility was the organization and conduct of the laboratory instruction in biochemistry to freshman medical students.

CHARLES J. REED

CHARLES JOHN REED, one of the founders of the Electrochemical Society and its first secretary, as well as a member of the small group that established this magazine in 1902, died at his home in San Mateo, Calif., on April 11. Born in Iowa on June 29, 1858, he received the A.B. degree from the University of Michigan in 1881. With the exception of five early years spent in teaching his work was that of a consulting engineer.

AUGUSTUS F. MEEHAN, president of the Roos-Meehan Foundries, recently died in a Cincinnati hospital at the age of 61. In 1925 he established the first 100 per cent electrically operated steel foundry in the country. The previous year Mr. Meehan invented, developed and put on the market Meehanite metal, and two years later organized the Meehanite Metal Corp.

ISAAC W. DRUMMOND, former chairman of the board of directors of the Devoe & Reynolds Co., died recently at his home in New York City. He was 77 years old. His death was caused by a heart ailment.

Dr. Drummond joined the paint manufacturers as a chemist, became a director in 1922, and chairman of the board the following year. He retired in September, 1928.

NIELS C. ORTVED, president of the Universal Process Co. of Detroit, Mich., died in that city on April 5. He was born in Denmark in 1871. After graduating from the University of Copenhagen he came to America and engaged in chemical work in several distilleries. In 1906 he joined Hiram Walker & Sons, Ltd., at Walkerville, Ont., where he remained as chief chemist for over 25 years.

J. B. GREEN, founder and president of the Chicago Steel and Wire Co. and Fusion Welding Corp of Chicago, Ill., died April 24, at St. Luke's Hospital. Mr. Green was born in Chicago 47 years ago, and in 1910 graduated from Cornell University. He was widely known for his writings and lectures on arc welding.

ERNEST HOPKINSON, vice-president and a director of the United States Rubber Co., died recently at his home in New York City after an illness of six months. He would have been 61 years old on May 20.

Mr. Hopkinson was born in Chester, England, and came to America as a young man. Two years after graduation from college he joined the Peerless Rubber Co., a subsidiary of the United States Rubber Co., and remained in the patent department of the organization until his death. Although not a chemist he held hundreds of patents in the rubber and chemical fields. One of his best known developments is the spray drying of latex which is used largely at the Sumatra plantations.

He was chairman and a director of the Naugatuck Chemical Co. and a director of the Dominion Rubber Co., Ltd., the G. & J. Tire Co., Malayan American Plantations, Ltd., the Rubber Regenerating Co., the United States Rubber Plantations, Inc., and the United States Tire Co.

WILLIAM ROBERTSON, retired manager of the Albany plant of the Paper Makers Chemical Corp., died on May 4. He was 71 years old. Born in Denny, Scotland in 1861, he came to this country at the age of 25. His first job was with a paper mill in Massachusetts. After serving various companies as plant superintendent and as chemical and naval stores salesman, he organized the Empire Size and Chemical Corp. in Albany, N. Y., in 1918. This company became affiliated with Paper Makers Chemical Co. in 1920. Mr. Robertson retired from active service at the beginning of this year.

# CHEMICAL ECONOMICS

**Based on consumption of electrical power, domestic production of chemicals in May registered a gain of slightly more than 12 per cent over the preceding month and about one and one-half per cent over the corresponding period of last year. Practically all branches of the chemical industry shared in the advance.**

UPTURNS in manufacturing operations in the last month have been so general that a notable improvement in industry as a whole is conceded. Grains and other natural products not only have commanded higher prices but also have found broader markets. The so-called heavy industries, including steel, metallurgical, and automotive, have expanded to a far greater degree than had been anticipated. Steel production, which many regard as the leading business barometer, reached a 23 month high in May. Daily tire production in one of the largest tire plants at the end of May was reported to be 166 per cent of the daily average for the preceding 12 months. These reports are typical with variations for the rate of increase in the several industries.

With the gain in manufacturing there has been a corresponding increase in demand for materials. With prices on an upward trend there was some inclination to attribute the buying movement to a desire on the part of manufacturers to increase inventories in anticipation of higher prices to follow. Different surveys have denied the accuracy of this contention and it seems well established that consumer buying has been responsible for the activity.

Furthermore the reports for May are being duplicated with reference to business in the first half of June with further expansion detailed for many lines.

Because of their wide use in industry, chemicals naturally were affected by the general pick-up in business. Reports of increased sales are difficult to translate into definite terms of increase. Production of chemicals, however, as measured by the consumption of electrical energy at chemical plants not only recorded a gain of slightly more than 12 per cent over the preceding month but surpassed the total reported for May last year.

The index number for chemical production in May was 116.5 which compares with 104.0 for April and with 114.8 for May, 1932. Increased plant operations were reported for practically every branch of the chemical industry.

#### Department of Commerce Report

Reports compiled by the Department of Commerce state that business activity throughout the country in May showed improvement over the corresponding period of the preceding year for the first time since 1929.

Virtually all of the major indicators of business, the department's business survey showed, were higher than in May, 1932, and in such industries as automobiles, iron and steel, textiles and food processing the increases have been substantial.

"Retail trade," it was stated, "has improved markedly and the distribution of merchandise by the railroads in the second week of May exceeded last year's levels. Construction contracts awarded up to the middle of the month have continued extremely small."

The survey found that pay rolls increased 4.6 per cent and employed 1.9 per cent over March.

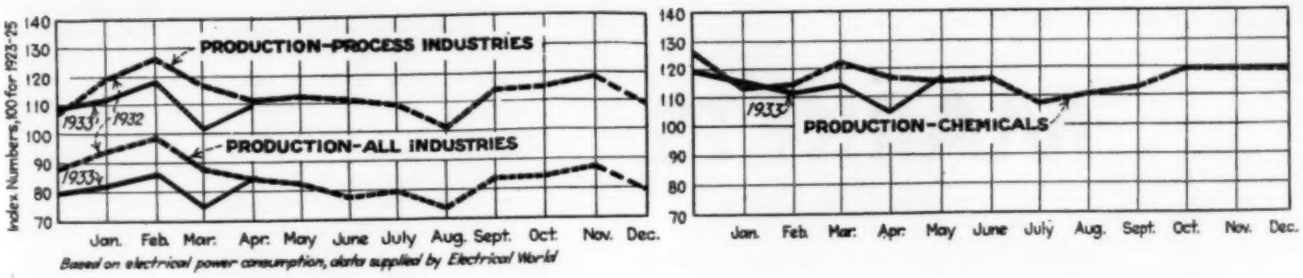
"Prices of both commodities and securities have advanced in response to the announced policies and plans of the Administration and as a result of the improvement in business. Many raw materials and food products have risen rapidly and the disparity between prices of such commodities and the prices of finished goods has been substantially reduced."

An encouraging note regarding foreign trade is found in the fact that exports of crude coal-tar products from the United States during the first quarter of this year totaled almost a million dollars more than those in the first quarter of 1932. Imports of these products were slightly lower in this year's quarter.

The increase in exports of benzene followed a prolonged decline in shipments of this commodity. Purchases in the 1933 quarter were chiefly by France, 710,168 gallons ($122,740), and Japan, 292,411 gallons ($83,386). France was also the chief tar market in 1933, taking 58,806 barrels ($136,689); followed by Germany, 39,572 barrels ($92,000), and Belgium, 19,653 barrels ($45,000). Pitch showed the most marked increase, due almost entirely to the shipment in 1933 of 79,960 tons, valued at $1,058,386, to France. The small creosote oil shipments went to Canada, 19,672 gallons ($3,601); Panama, 5,200 gallons ($824); Mexico, 1,272 gallons ($369); and Venezuela, 1,325 gallons ($277).

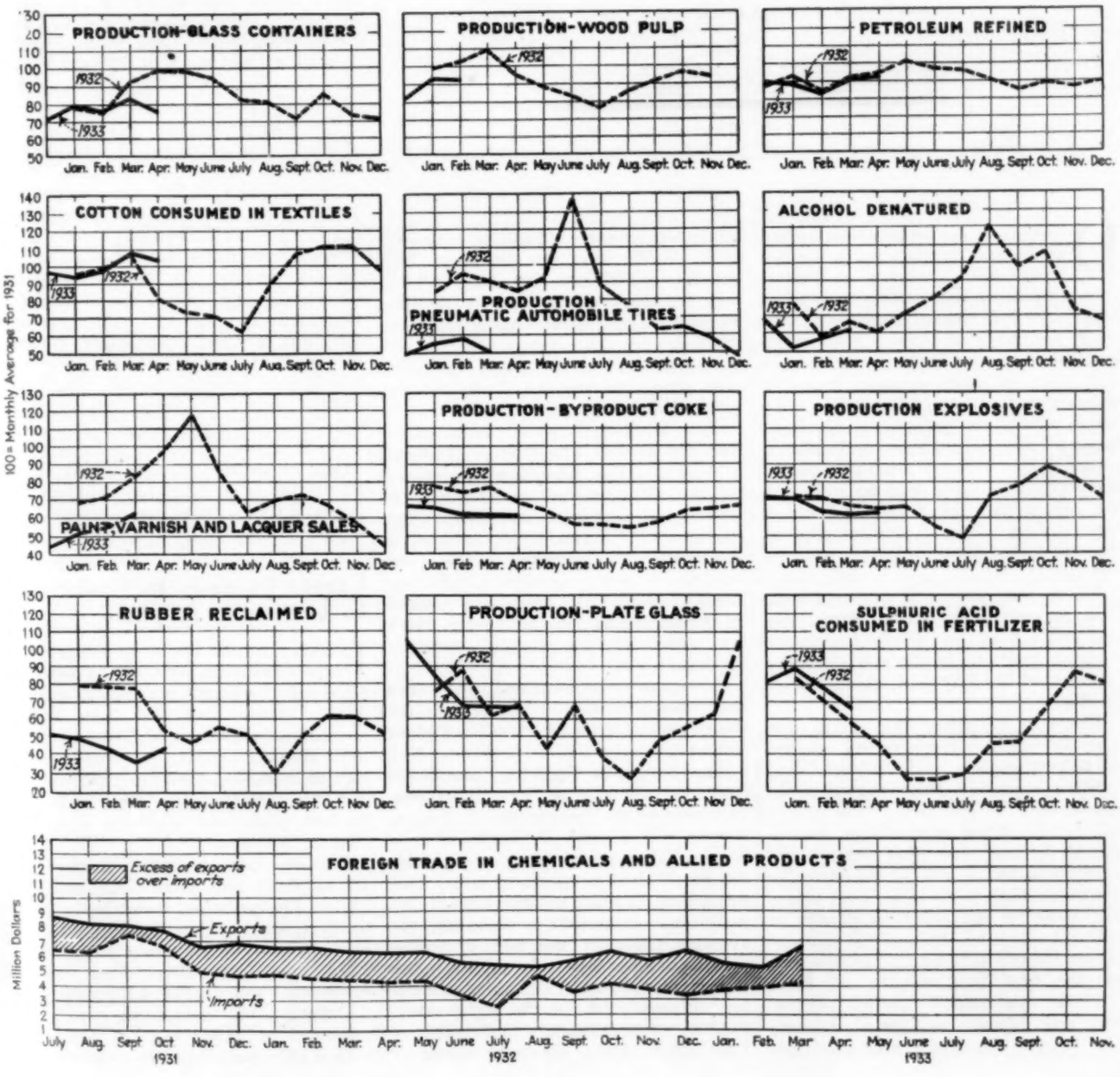
## Value of Canadian Chemical Output Lower in 1932

PRODUCTION of chemicals and allied products in Canada in 1932, was valued at $95,540,000, 9 per cent less than the corresponding figure for 1931 of $105,500,000, according to preliminary figures just issued by the Dominion Bureau of Statistics at Ottawa. Of the 14 groups into which the industry was divided only 4 showed slightly higher values than in 1931. The acids, alkalies and salts gained 4 per cent to $11,358,000, and medicinals and pharmaceuticals, the most important group in point of value, advanced slightly to $18,146,000. Imports of chemicals and allied products for the calendar year 1932 according to the preliminary figures, which however included only principal commodities, fell 12 per cent from 1931, to $32,000,000. The United States continued to be the leading source but its share declined somewhat to $21,000,000, although the United Kingdom's increased slightly to $4,864,000. Exports of chemicals and allied products from Canada in 1932 advanced a little to $11,283,000, of which $4,750,000 was destined for the United States.




*Based on electrical power consumption, data supplied by Electrical World*

# TRENDS OF PRODUCTION AND CONSUMPTION



# MARKETS

**Delivery of chemicals against running contracts assumed larger proportions in the last month and spot trading showed a decided increase not only in the general total but also in the variety of products in demand. Many industries which previously had curtailed their raw material requirements were again prominent in the market. Prices were firmer with a rising tendency.**

DEMAND for chemicals has taken on broader proportions in the last month with a revival of interest shown by some industries which for a long time had taken much less than their normal allotments. The metallurgical industries for example, for the first time in many months, began to increase commitments for raw materials. More interest in the market also was taken by the rubber, glass, and ceramic trades. The different branches of the textile industry have held up well during the months of depression and a better than seasonal movement of chemicals to that industry still is reported.

Paints, varnishes, and pigments were slow to start their active season this year but a good part of the backwardness was made up by the active trading experienced in May and which still is in effect.

The rise in prices for cotton and other agricultural products has resulted in larger buying of fertilizers and fertilizer materials than seemed probable earlier in the year. The larger call for fertilizer materials is demonstrated by the fact that imports of fertilizer materials, during the first four months of 1933, were 15 per cent larger than those for the first four months of 1932. Imports of ammonium sulphate totaled 169,605 tons against 88,448 tons for the first four months of 1932. Calcium cyanamide, calcium nitrate, urea and calurea and guano imports were larger. Imports of sodium nitrate amounted to only 3,093 tons compared with 44,270 tons for the first four months of 1932 and more than 300,000 tons for the first four months of 1931. Imports of phosphate materials were smaller than last year. Muriate of potash and sulphate of potash shipments were larger but kainite and manure salts receipts were smaller. Imports of "other fertilizers" were much larger than for the first four months of 1932.

Sales of carbon black have been aided by the rise in tire manufacture as well as by increased call from other consumers. Export inquiry for carbon black also was reported to be more active. A new organization, Carbon Black Export, Inc., has been formed to handle export sales of carbon black for some of the largest domestic producers.

A report from Hanford, Cal., says that plans are under consideration for the construction of a carbon black plant in that vicinity.

The Bureau of Chemistry and Soils, from its compilation of information furnished by the manufacturers of cups, reports that a total of 11,088,333 cups were sold last winter for use in gathering the 1933-34 naval stores crop. Not since 1930-31 have anywhere nearly so many cups been sold in a season, the average sales for the two preceding seasons having been only slightly more than 2,000,000 cups. The average number of cups sold for the eight years, 1923-31, approximated 18,650,000 or 1,865 crops of new cups each season.

The Bureau of Mines has issued a report which states that production of sodium compounds in 1932, not including common salt, from natural salines and brines found in the United States, as indicated by sales or shipments by producers, amounted to 269,496 short tons, valued at $4,122,238. These figures which include the output of sodium carbonate (soda ash and trona), sodium bicarbonate, sodium sulphate (salt cake and glauber salt), and sodium borate (borax and kernite), show a decrease in both quantity and value compared with the output in 1931 of 289,590 short tons, valued at $6,352,971.

The sodium carbonates reported in 1932 were from California and amounted to 55,377 short tons, valued at $888,052, compared with 78,530 tons, valued at $1,223,544 in 1931, a decrease of 29 per cent in quantity and 27 per cent in value. They were produced in California from Owens Lake, by the Pacific Alkali Co.; and the Natural Soda Products Co.; and from Searles Lake, by the West End Chemical Co.

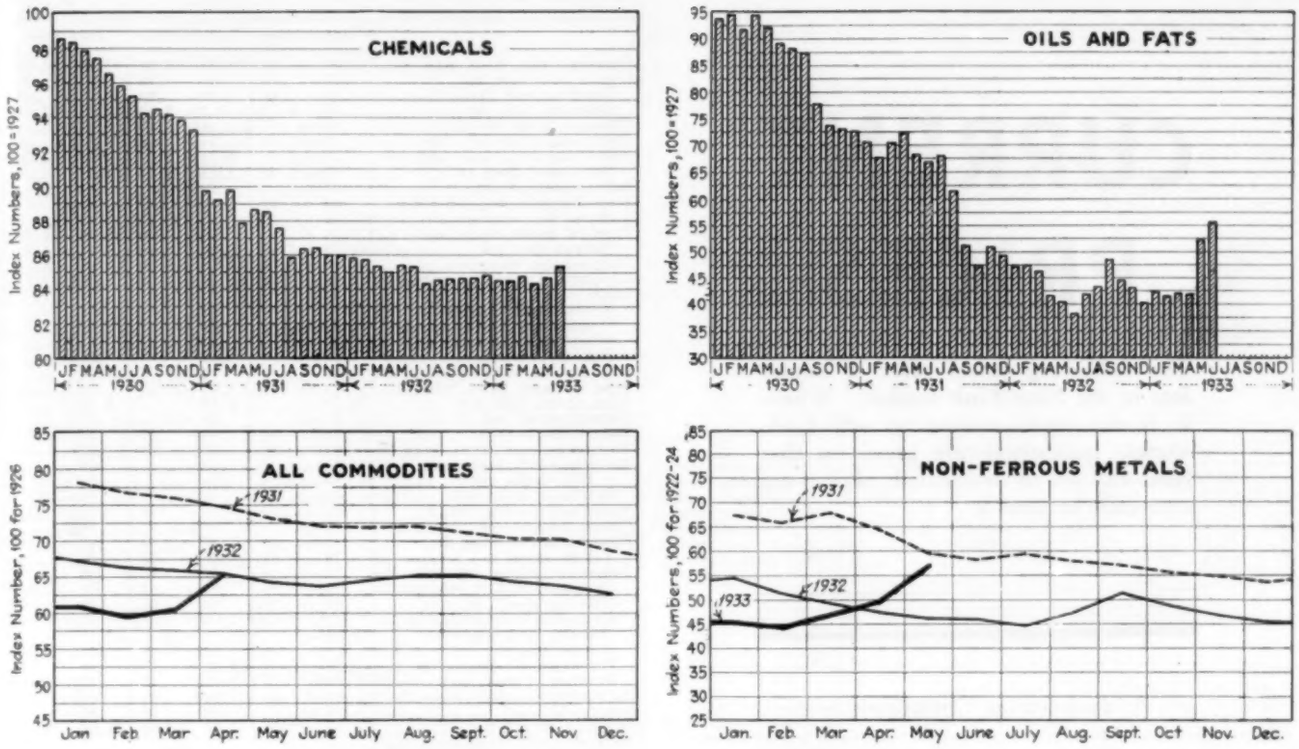
The sodium sulphate (salt cake and glauber salt) shipped amounted to 32,204 tons, valued at $210,342 in 1932, compared with 32,510 tons, valued at $198,132 in 1931. The principal production of salt cake was from Camp Verde, Arizona, by the Arizona Chemical Co., and by the Rhodes Alkali & Chemical Corp., near Mina, Nevada. Hydrated sodium sulphate (glauber salt) was produced near Casper, Wyoming, by W. E. Pratt, and by the Columbian Hog & Cattle Powder Co. The Iowa Soda Products Co. mined glauber salt near Rawlins, Wyoming, and shipped to Council Bluffs, Iowa, for refining. No output of sodium sulphate was reported from Utah or Washington although deposits in both States were reported as under development.

## Canada Increases Its Trade In Ammonium Sulphate

PEAK records were established in production, imports and exports of ammonium sulphate in Canada during 1932. Output increased from 28,354 short tons in 1931 to 57,770 tons. Six firms reported production,—three operators of byproduct ovens in Ontario, one in Nova Scotia, and one each byproduct plant and synthetic plant in British Columbia.

Exports from Canada increased to 38,741 short tons from 5,627 tons in 1931. The principal countries of destination were: Hawaii, 10,918 tons; United States, 10,595 tons; Hong Kong, 5,274 tons; Netherland East Indies, 4,848 tons; and China, 4,770 tons.

Imports of ammonium sulphate amounted to 13,811 tons as compared with 12,830 tons in 1931.




# PRICE TRENDS—CHEM. & MET.'S WEIGHTED INDEXES

WITH THE all-commodity price index moving upward sharply in recent weeks, the tendency in all markets has been toward higher values. The widest price fluctuations have been noted in the case of those commodities which led in the downward movement of prices. For example many metals declined so drastically that sales prices went below the level of production costs. With a revival in buying, these products responded more quickly to the price stimulus.

In the case of chemicals, many selections were unchanged so far as open quotations were concerned but actually sales went through at whatever prices competitive influences dictated. Hence the real decline in chemical prices has not been reflected in the quotations as published. In like manner, the advance in prices in the last month or more is not indicated by the price tables because the advances have merely consisted in bringing actual trading transactions up to the quoted levels or more nearly approaching the quoted levels than has been the case in the last year.

In cases where quoted levels were largely adhered to, the recent price trend for chemicals has followed the general trend. As cases in point, it may be mentioned that the lead pigments, tin salts, and other metal derivatives have moved up and down in price according to the position of the basic raw material.

Back of the uplift in values has been the increase in manufacturing operations which has brought out decided gains in the movement of chemicals. This condition promises to continue for some time and offers a logical reason for the maintenance of prices.

### Industry Control a Price Factor

Industry control as defined in the national recovery program may become a factor of considerable importance in a long-term view of chemical prices. In the past price-cutting competition, especially during the contracting season, has been the most important single price influence and if industry control can succeed in eliminating this factor as well as preserve an equitable balance between production and consumption the outlook for stabilized prices will be greatly enhanced.

Vegetable oils, like metals and some of the other natural products, went to lower price levels than many of the manufactured products. The reaction has been correspondingly more accentuated. Prices for vegetable, animal, and fish oils have been steadily advancing and the average level is now considerably above that reported at any time in 1932. The higher prices have proved no deterrent to business as consuming industries have been steady buyers in recent weeks. Animal fats responded to higher production costs with price stability further augmented by the wider consuming demand.

### Chem. & Met. Weighted Index of Chemical Prices

Base = 100 for 1927

| | |
|---|---|
| **This month** | **85.37** |
| Last month | 84.80 |
| June, 1932 | 85.27 |
| June, 1931 | 88.49 |

While many basic chemicals have not changed in price, a stronger tone underlies the entire market. The most pronounced advances have occurred in the case of metal salts where production costs have moved up sharply by the rise in value for metals.

### Chem. & Met. Weighted Index of Prices for Oils and Fats

Base = 100 for 1927

| | |
|---|---|
| **This month** | **55.73** |
| Last month | 52.37 |
| June, 1932 | 38.30 |
| June, 1931 | 64.39 |

The upward price movement continued last month and was practically inclusive throughout the markets for vegetable, animal, and fish oils as well as for animal fats. Foreign oils which previously resisted price advances are now moving in harmony with other oils.

# CURRENT PRICES

The following prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to June 9.

## Industrial Chemicals

| | Current Price | Last Month | Last Year |
|---|---|---|---|
| Acetone, drums, lb. | $0.08½–$0.09 | $0.08½–$0.09 | $0.10 –$0.11 |
| Acid, acetic, 28%, bbl., cwt. | 2.78 – 3.03 | 2.65 – 2.90 | 2.65 – 2.90 |
| Glacial 99%, tanks | 9.33 – | 8.89 – | 8.89 – |
| drs | 9.58 – 9.83 | 9.14 – 9.39 | 9.14 – 9.39 |
| U. S. P. reagent, c'bys | 9.64 – 9.89 | 9.64 – 9.89 | 9.64 – 9.89 |
| Boric, bbl., lb. | .04½– .05 | .04½– .05 | .04½– .05 |
| Citric, kegs, lb. | .29 – .31 | .29 – .31 | .31 – .32 |
| Formic, bbl., lb. | .10 – .11 | .10 – .11 | .10 – .11 |
| Gallic, tech., bbl., lb. | .55 – .60 | .50 – .55 | .50 – .55 |
| Hydrofluoric 30% carb., lb. | .06 – .07 | .06 – .07 | .06 – .07 |
| Lactic, 44%, tech., light, bbl., lb. | .11½– .12 | .11½– .12 | .11½– .12 |
| 22%, tech., light, bbl., lb. | .05½– .06 | .05½– .06 | .05½– .06 |
| Muriatic, 18° tanks, cwt. | 1.00 – 1.10 | 1.00 – 1.10 | 1.00 – 1.10 |
| Nitric, 36°, carboys, lb. | .05 – .05½ | .05 – .05½ | .05 – .05½ |
| Oleum, tanks, wks., ton | 18.50 –20.00 | 18.50 – | 18.50 –20.00 |
| Oxalic, crystals, bbl., lb. | .11 – .11½ | .11 – .11½ | .11 – .12 |
| Phosphoric, tech., c'bys., lb. | .08½– .09 | .08½– .09 | .08½– .09 |
| Sulphuric, 60°, tanks, ton | 11.00 –11.50 | 11.00 –11.50 | 11.00 –11.50 |
| Sulphuric, 66°, tanks, ton | 15.50 – | 15.50 – | 15.50 – |
| Tannic, tech., bbl., lb. | .23 – .35 | .23 – .35 | .23 – .35 |
| Tartaric, powd., bbl., lb. | .20 – .21 | .20 – .21 | .23½– .24 |
| Tungstic, bbl., lb. | 1.40 – 1.50 | 1.40 – 1.50 | 1.40 – 1.50 |
| Alcohol, ethyl, 190 p'f., bbl., gal. | 2.53½– | 2.53½– | 2.53½– |
| Alcohol, Butyl, tanks, lb. | .095– | .095– | .113– |
| Alcohol, Amyl | – | – | – |
| From Pentane, tanks, lb. | .143– | .143– | .182– |
| Denatured, 190 proof | | | |
| No. 1 special dr., gal. | .34½– | .34½– | .34½– |
| No. 5, 188 proof, dr., gal. | .38½– | .38½– | .35½– |
| Alum, ammonia, lump, bbl., lb. | .03 – .04 | .03 – .04 | .03 – .04 |
| Chrome, bbl., lb. | .04½– .05 | .04½– .05 | .04½– .05 |
| Potash, lump, bbl., lb. | .03 – .04 | .03 – .04 | .03 – .04 |
| Aluminum sulphate, com., bags, cwt. | 1.25 – 1.40 | 1.25 – 1.40 | 1.25 – 1.40 |
| Iron free, bg., cwt. | 1.90 – 2.00 | 1.90 – 2.00 | 1.90 – 2.00 |
| Aqua ammonia, 26°, drums lb. | .02½– .03 | .02½– .03 | .02½– .03 |
| tanks, lb. | .02½– .02½ | .02½– .02½ | .02½– .02½ |
| Ammonia, anhydrous, cyl., lb. | .15½– .15½ | .15½– .15½ | .15½– .15½ |
| tanks, lb. | .05 – | .05 – | .05½– |
| Ammonium carbonate, powd tech., casks, lb. | .08 – .12 | .08 – .12 | .10½– .11 |
| Sulphate, wks., cwt. | 1.05 – | 1.15 – | 1.00 – |
| Amylacetate tech., tanks, lb., gal | .135– | .135– | .16 – |
| Antimony Oxide, bbl., lb. | .07½– .08 | .07½– .08 | .06½– .08 |
| Arsenic, white, powd., bbl., lb. | .04 – .04½ | .04 – .04½ | .04 – .04½ |
| Red, powd., kegs, lb. | .10½– .11 | .10½– .11 | .09 – .10 |
| Barium carbonate, bbl., ton | 56.50 –58.00 | 56.50 –58.00 | 56.50 –58.00 |
| Chloride, bbl., ton | 61.50 –65.00 | 63.00 –65.00 | 63.00 –65.00 |
| Nitrate, cask, lb. | .07½– .07½ | .07½– .07½ | .07 – .07½ |
| Blanc fixe, dry, bbl., lb. | .03 – .04 | .03 – .04 | .03½– .04 |
| Bleaching powder, f.o.b., wks., drums, cwt. | 1.75 – 2.00 | 1.75 – 2.00 | 1.75 – 2.00 |
| Borax, grain, bags, ton | 40.00 –45.00 | 40.00 –45.00 | 40.00 –45.00 |
| Bromine, cs., lb. | .36 – .38 | .36 – .38 | .36 – .38 |
| Calcium acetate, bags | 2.75 – | 2.50 – | 2.50 – |
| Arsenate, dr., lb. | .05½– .06½ | .05½– .06½ | .05½– .06½ |
| Carbide drums, lb. | .05 – .06 | .05 – .06 | .05 – .06 |
| Chloride, fused, dr., wks., ton | 17.50 – | 17.50 – | 18.00 – |
| flake, dr., wks., ton | 19.50 – | 19.50 – | 21.00 – |
| Phosphate, bbl., lb | .07½– .08 | .07½– .08 | .08 – .08½ |
| Carbon bisulphide, drums, lb. | .05 – .06 | .05 – .06 | .05 – .06 |
| Tetrachloride drums, lb. | .05½– .06 | .05½– .06 | .06½– .07 |
| Chlorine, liquid, tanks, wks., lb. | .01½– | .01½– | .01½– |
| Cylinders | .05½– .06 | .05½– .06 | .05 – .06 |
| Cobalt oxide, cans, lb. | 1.15 – 1.25 | 1.15 – 1.25 | 1.25 – 1.35 |
| Copperas, bgs., f.o.b. wks., ton | 14.00 –15.00 | 14.00 –15.00 | 13.00 –14.00 |
| Copper carbonate, bbl., lb. | .07 – .16 | .07 – .16 | .07 – .16 |
| Cyanide, tech., bbl., lb. | .39 – .44 | .39 – .44 | .39 – .44 |
| Sulphate, bbl., cwt. | 3.50 – 3.75 | 3.25– 3.50 | 2.75 – 2.90 |
| Cream of tartar, bbl., lb. | .14½– .15 | .14½– .15 | .18½– .19 |
| Diethylene glycol, dr., lb. | .14 – .16 | .14 – .16 | .14 – .16 |
| Epsom salt, dom., tech., bbl., cwt. | 1.70 – 2.00 | 1.70 – 2.00 | 1.70 – 2.00 |
| Imp., tech., bags, cwt. | 1.35 – 1.40 | 1.15 – 1.25 | 1.15 – 1.25 |
| Ethyl acetate, drums, lb. | .08½– | .08½– | .10 – |
| Formaldehyde, 40%, bbl., lb. | .06 – .07 | .06 – .07 | .06 – .07 |
| Furfural, dr., contract, lb. | .10 – .17½ | .10 – .17½ | .10 – .17½ |
| Fusel oil, crude, drums, gal. | .75 – | 1.10 – 1.20 | 1.10 – 1.20 |
| Refined, dr., gal. | 1.25 – 1.30 | 1.80 – 1.90 | 1.80 – 1.90 |
| Glaubers salt, bags, cwt. | 1.00 – 1.10 | 1.00 – 1.10 | 1.00 – 1.10 |
| Glycerine, c.p., drums, extra, lb. | .10½– .10½ | .10½– .10½ | .10½– .11 |
| Lead: | | | |
| White, basic carbonate, dry casks, lb. | .06½– | .06 – | .06½– |
| White, basic sulphate, sck., lb. | .06 – | .05½– | .06 – |
| Red, dry, sck., lb. | .07½– | .07 – | .06½– |
| Lead acetate, white crys., bbl., lb. | .10 – .11 | .10 – .11 | .10 – .11 |
| Lead arsenate, powd., bbl., lb. | .09 – .13 | .09 – .13 | .10 – .14 |
| Lime, chem., bulk, ton | 8.50 – | 8.50 – | 8.50 – |
| Litharge, pwd., csk, lb. | .06½– | .06 – | .05½– |
| Lithophone, bags, lb. | .04½– .05 | .04½– .05 | .04½– .05 |
| Magnesium carb., tech., bags, lb. | .05½– .06 | .05½– .06 | .05½– .06 |
| Methanol, 95%, tanks, gal. | .33 – | .33 – | .33 – |
| 97%, tanks, gal. | .34 – | .34 – | .34 – |
| Synthetic, tanks, gal. | .35½– | .35½– | .35½– |
| Nickel salt, double, bbl., lb | .12 – .12½ | .11 – .11½ | .10½– .11 |
| Orange mineral, csk., lb. | .10 – | .09½– | .09½– |
| Phosphorus, red, cases, lb. | .45 – .46 | .42 – .44 | .42 – .44 |
| Yellow, cases, lb. | .28 – .32 | .28 – .32 | .31 – .32 |
| Potassium bichromate, casks, lb. | .07½– .08 | .07 – .08 | .08 – .08½ |
| Carbonate, 80-85%, calc. csk., lb | .05½– .06 | .05½– .06 | .05 – .06 |
| Chlorate, powd., lb. | .08½– .08½ | .08½– .08½ | .08 – .08½ |
| Hydroxide (c'stic potash) dr., lb. | .07½– .07½ | .06½– .06½ | .06½– .06½ |
| Muriate, 80% bgs., ton | 37.15 – | 37.15 – | 37.15 – |
| Nitrate, bbl., lb. | .05½– .06 | .05½– .06 | .05½– .06 |
| Permanganate, drums, lb. | .16 – .16½ | .16 – .16½ | .16 – .16½ |
| Prussiate, yellow, casks, lb. | .16½– .17 | .16½– .17 | .18½– .19 |
| Sal ammoniac, white, casks, lb. | .04½– .05 | .04½– .05 | .04½– .05 |
| Salsoda, bbl., cwt. | .90 – .95 | .90 – .95 | .90 – .95 |
| Salt cake, bulk, ton | 13.00 –15.00 | 13.00 –15.00 | 16.00 –18.00 |
| Soda ash, light, 58%, bags, contract, cwt. | 1.20 – | 1.20 – | 1.15 – |
| Dense, bags, cwt. | 1.22½– | 1.22½– | 1.17½– |
| Soda, caustic, 76%, solid, drums, contract, cwt. | 2.50 – 2.75 | 2.50 – 2.75 | 2.50 – 2.75 |
| Acetate, works, bbl., lb. | .04½– .05 | .04½– .05 | .05 – .05½ |
| Bicarbonate, bbl., cwt. | 1.85 – 2.00 | 1.85 – 2.00 | 1.85 – 2.00 |
| Bichromate, casks, lb. | .044– .05 | .044– .05 | .05 – .06 |
| Bisulphate, bulk, ton | 14.00 –16.00 | 14.00 –16.00 | 14.00 –16.00 |
| Bisulphite, bbl., lb. | .03½– .04 | .03½– .04 | .03½– .04 |
| Chlorate, kegs, lb. | .05½– .07½ | .05½– .07½ | .05½– .07½ |
| Chloride, tech., ton | 12.00 –14.75 | 12.00 –14.75 | 12.00 –14.00 |
| Cyanide, cases, dom., lb. | .15½– .16 | .15½– .16 | .15½– .16 |
| Fluoride, bbl., lb. | .07 – .08 | .07 – .08 | .07½– .08 |
| Hyposulphite, bbl., lb. | 2.40 – 2.50 | 2.40 – 2.50 | 2.40 – 2.50 |
| Metasilicate, bbl., cwt. | 3.25 – 3.40 | 3.25 – 3.40 | 3.60 – |
| Nitrate, bags, cwt. | 1.345– | 1.345– | 1.77 – |
| Nitrite, casks, lb. | .07½– .08 | .07½– .08 | .07½– .08 |
| Phosphate, dibasic, bbl., lb. | .02 – .023 | .018– .02 | .0255 – .0275 |
| Prussiate, yel. drums, lb. | .11½– .12 | .11½– .12 | .11½– .12 |
| Silicate (40° dr.) wks. cwt. | .70 – .75 | .70 – .75 | .70 – .75 |
| Sulphide, fused, 60-62%, dr., lb. | .02½– .03½ | .02½– .03 | .02½– .03 |
| Sulphite, cyrs., bbl., lb. | .03 – .03½ | .03 – .03½ | .03 – .03½ |
| Sulphur, crude at mine, bulk, ton | 18.00 – | 18.00 – | 18.00 – |
| Chloride, dr., lb. | .03½– .04 | .03½– .04 | .03½– .04 |
| Dioxide, cyl., lb. | .06½– .07 | .06½– .07 | .06½– .07 |
| Flour, bag, cwt. | 1.55 – 3.00 | 1.55 – 3.00 | 1.55 – 3.00 |
| Tin bichloride, bbl., lb. | nom.– | nom.– | nom.– |
| Oxide, bbl., lb. | .43 – | .37½– | .25½– |
| Crystals, bbl., lb. | .33½– | .29½– | .22½– |
| Zinc chloride, gran., bbl., lb. | .06½– .06½ | .06½– .06½ | .06½– .06½ |
| Carbonate, bbl., lb. | .10½– .11 | .10½– .11 | .10½– .11 |
| Cyanide, dr., lb. | .38 – .42 | .38 – .42 | .41 – .42 |
| Dust, bbl., lb. | .06½– .07 | .06½– .06½ | .04½– .05 |
| Zinc oxide, lead free, bag, lb. | .05½– | .05½– | .05½– |
| 5% lead sulphate, bags, lb. | .05½– | .05½– | .05½– |
| Sulphate, bbl., cwt. | 3.00 – 3.25 | 3.00 – 3.25 | 3.00 – 3.25 |

## Oils and Fats

| | Current Price | Last Month | Last Year |
|---|---|---|---|
| Castor oil, No. 3, bbl., lb. | $0.08½–$0.09 | $0.08½–$0.09 | $0.09½–$0.10 |
| Chinawood oil, bbl., lb. | .06½– | .05½– | .05½– |
| Coconut oil, Ceylon, tanks, N. Y. lb. | .03½– | .03½– | .03½– |
| Corn oil crude, tanks, (f.o.b. mill), lb | .04½– | .04½– | .02½– |
| Cottonseed oil, crude (f.o.b. mill), tanks, lb. | .04½– | .04 – | .02½– |
| Linseed oil, raw car lots, bbl., lb. | .09 – | .087– | .059– |
| Palm, Lagos, casks, lb. | .04½– | .03½– | .03½– |
| Palm Kernel, bbl., lb. | .04½– | .04½– | .04½– |
| Peanut oil, crude, tanks (mill), lb. | .04½– | .04½– | .02½– |
| Rapeseed oil, refined, bbl., gal. | .49 – .50 | .40 – .42 | .30 – .32 |
| Soya bean, tank (f.o.b. Coast), lb. | nom.– | nom.– | nom.– |
| Sulphur (olive foots), bbl., lb. | .05½– | .05 – | .04½– |
| Cod, Newfoundland, bbl., gal. | .24 – .25 | .23 – .24 | .21 – .22 |
| Menhaden, light pressed, bbl., lb. | .047– | .041– | .04 – |
| Crude, tanks (f.o.b. factory), gal. | .15 – | .10½– | nom.– |
| Grease, yellow, loose, lb. | .03½– | .03 – | .02 – |
| Oleo stearine, lb. | .05 – | .05 – | .04 – |
| Red oil, distilled, d.p. bbl., lb. | .06½– | .06½– | .06½– |
| Tallow, extra, loose, lb. | .03½– | .03½– | .01½– |

## Coal-Tar Products

| | Current Price | Last Month | Last Year |
|---|---|---|---|
| Alpha-naphthol, crude, bbl., lb. | $0.60 -$0.65 | $0.60 -$0.65 | $0.60 -$0.62 |
| Refined, bbl., lb. | .80 - .85 | .80 - .85 | .80 - .85 |
| Alpha-naphthylamine, bbl., lb. | .32 - .34 | .32 - .34 | .32 - .34 |
| Aniline oil, drums, extra, lb. | .14½- .15 | .14½- .15 | .14½- .15 |
| Aniline salts, bbl., lb. | .24 - .25 | .24 - .25 | .24 - .52 |
| Benzaldehyde, U.S.P., dr., lb. | 1.10 - 1.25 | 1.10 - 1.25 | 1.10 - 1.25 |
| Benzidine base, bbl., lb. | .65 - .67 | .65 - .67 | .65 - .67 |
| Benzoic acid, U.S.P., kgs, lb. | .48 - .52 | .48 - .52 | .48 - .52 |
| Benzyl chloride, tech., dr., lb. | .30 - .35 | .30 - .35 | .30 - .35 |
| Benzol, 90%, tanks, works, gal. | .22 - .23 | .22 - .23 | .20 - .21 |
| Beta-naphthol, tech., drums, lb. | .22 - .24 | .22 - .24 | .22 - .24 |
| Cresol, U. S. P., dr., lb. | .10½- .11 | .10½- .11 | .10½- .11 |
| Cresylic acid, 97%, dr., wks., gal. | .42 - .45 | .42 - .45 | .49 - .52 |
| Diethylaniline, dr., lb. | .55 - .58 | .55 - .58 | .55 - .58 |
| Dinitrophenol, bbl., lb. | .29 - .30 | .29 - .30 | .29 - .30 |
| Dinitrotoluen, bbl. lb. | .16 - .17 | .16 - .17 | .16 - .17 |
| Dip oil 25% dr., gal. | .23 - .25 | .23 - .25 | .23 - .25 |
| Diphenylamine, bbl., lb. | .38 - .40 | .38 - .40 | .38 - .40 |
| H-acid, bbl., lb. | .65 - .70 | .65 - .70 | .65 - .70 |
| Naphthalene, flake, bbl., lb. | .04½- .05 | .04½- .05 | .03½- .04¼ |
| Nitrobenzene, dr., lb. | .08½- .09 | .08½- .09 | .08½- .10 |
| Para-nitraniline, bbl., lb. | .51 - .55 | .51 - .55 | .51 - .55 |
| Phenol, U.S.P., drums, lb. | .14½- .15 | .14½- .15 | .14½- .15 |
| Picric acid, bbl., lb. | .30 - .40 | .30 - .40 | .30 - .40 |
| Pyridine, dr., gal. | .90 - .95 | .90 - .95 | 1.50 - 1.80 |
| R-salt, bbl., lb. | .40 - .44 | .40 - .44 | .40 - .44 |
| Resorcinal, tech., kegs, lb. | .65 - .70 | .65 - .70 | .65 - .70 |
| Salicylic acid, tech., bbl., lb. | .40 - .42 | .40 - .42 | .33 - .35 |
| Solvent naphtha, w.w., tanks, gal. | .26 - | .26 - | .26 - |
| Tolidine, bbl., lb. | .88 - .90 | .88 - .90 | .86 - .88 |
| Toluene, tanks, works, gal. | .30 - | .30 - | .30 - |
| Xylene, com., tanks, gal. | .26 - | .26 - | .26 - |

## Miscellaneous

| | Current Price | Last Month | Last Year |
|---|---|---|---|
| Barytes, grd., white, bbl., ton. | $22.00-$25.00 | $22.00-$25.00 | $22.00-$25.00 |
| Casein, tech., bbl., lb. | .10½- .11½ | .08½- .10½ | .06 - .10½ |
| China clay, dom., f.o.b. mine, ton | 8.00 -20.00 | 8.00 -20.00 | 8.00 -20.00 |
| Dry colors: | | | |
| Carbon gas, black (wks.), lb. | .02½- .20 | .02½- .20 | .02½- .20 |
| Prussian blue, bbl., lb. | .35 - .36 | .35 - .36 | .35 - .36 |
| Ultramine blue, bbl., lb. | .06 - .32 | .06 - .32 | .06 - .32 |
| Chrome green, bbl., lb. | .26 - .27 | .26 - .27 | .27 - .30 |
| Carmine red, tins, lb. | 3.65 - 3.75 | 3.65 - 3.75 | 5.25 - 5.40 |
| Para toner, lb. | .80 - .85 | .80 - .85 | .75 - .80 |
| Vermilion, English, bbl., lb. | 1.20 - 1.30 | 1.20 - 1.30 | 1.45 - 1.50 |
| Chrome yellow, C. P., bbl., lb. | .15 - .15½ | .15 - .15½ | .16 - .16½ |
| Feldspar, No. 1 (f.o.b. N.C.), ton | 6.50 - 7.50 | 6.50 - 7.50 | 6.50 - 7.50 |
| Graphite, Ceylon, lump, bbl., lb. | .07 - .08½ | .07 - .08½ | .07 - .08½ |
| Gum copal Congo, bags, lb. | .06 - .08 | .06 - .08 | .06 - .08 |
| Manila, bags, lb. | .09 - .10 | .09 - .10 | .16 - .17 |
| Damar, Batavia, cases, lb. | .08½- .10½ | .08½- .10½ | .16 - .16½ |
| Kauri No. 1 cases, lb. | .20 - .25 | .20 - .25 | .45 - .48 |
| Kieselguhr (f.o.b. N.Y.), ton. | 50.00 -55.00 | 50.00 -55.00 | 50.00 -55.00 |
| Magnesite, calc, ton. | 40.00 - | 40.00 - | 40.00 - |
| Pumice stone, lump, bbl., lb. | .05 - .07 | .05 - .08 | .05 - .07 |
| Imported, casks, lb. | .03 - .40 | .03 - .40 | .03 - .35 |
| Rosin, H., bbl. | 4.75 - | 4.75 - | 3.80 - |
| Turpentine, gal. | .47 - | .48 - | .44½- |
| Shellac, orange, fine, bags, lb. | .19 - .20 | .19 - .20 | .25 - .27 |
| Bleached, bonedry, bags, lb. | .20 - .22 | .18 - .19 | .18 - .19 |
| T. N. bags, lb. | .11½- .12 | .09½- .10 | .10 - .11 |
| Soapstone (f.o.b. Vt.), bags, ton | 10.00 -12.00 | 10.00 -12.00 | 10.00 -12.00 |
| Talc, 200 mesh (f.o.b. Vt.), ton. | 8.00 - 8.50 | 8.00 - 8.50 | 8.00 - 8.50 |
| 300 mesh (f.o.b Ga.), ton. | 7.50 -10.00 | 7.50 -10.00 | 7.50 -11.00 |
| 225 mesh (f.o.b. N. Y.), ton. | 13.75 - | 13.75 - | 13.75 - |
| Wax, Bayberry, bbl., lb. | .14 - .15 | .14 - .15 | .16 - .20 |
| Beeswax, ref., light, lb. | .20 - .30 | .20 - .30 | .25 - .27 |
| Candelilla, bags, lb. | .09½- .10 | .09 - .10 | .13 - |
| Carnuba, No. 1, bags, lb. | .26 - .23 | .23 - .26 | .21 - .23 |
| Paraffine, crude | | | |
| 105-110 m.p., lb. | 02¾ - | .02 - | .03½- .03¾ |

## Price Changes During Month

| Advanced | Declined |
|---|---|
| Acetic acid | Turpentine |
| Acetate of lime | Ammonium sulphate |
| Arsenic, red | Fusel oil |
| Copper sulphate | |
| Lead, carbonate | |
| Lead oxides | |
| Nickel salts | |
| Tin salts | |
| Casein | |
| Vegetable oils | |

## Ferro-Alloys

| | Current Price | Last Month | Last Year |
|---|---|---|---|
| Ferrotitanium, 15-18%, ton. | $200.00- | $200.00- | $200.00- |
| Ferromanganese, 78-82%, ton. | 68.00- | 68.00- | 72.00-75.00 |
| Ferrochrome, 65-70%. | .09½- | .09½- | .10- |
| Spiegeleisen, 19-21% ton. | 24.00- | 24.00- | 27.00- |
| Ferrosilicon, 14-17%, ton. | 31.00- | 31.00- | 31.00- |
| Ferrotungsten, 70-80%, lb. | .95- 1.00 | .94- 1.00 | 1.00- 1.10 |
| Ferrovanadium, 30-40%, lb. | 2.60- 2.80 | 2.60- 2.80 | 3.05- 3.40 |

## Non-Ferrous Metals

| | Current Price | Last Month | Last Year |
|---|---|---|---|
| Copper, electrolytic, lb. | $0.08 - | $0.07 - | $0.05½- |
| Aluminum, 96-99%, lb. | .229- | .229- | .229- |
| Antimony, Chin. and Jap., lb. | .06½- | .06½- | .05½- |
| Nickel, 99%, lb. | .35 - | .35 - | .35 - |
| Monel metal blocks, lb. | .28 - | .28 - | .28 - |
| Tin, 5-ton lots, Straits, lb. | .37½- | .36- | .197- |
| Lead, New York, spot, lb. | .041- | .0365- | .03 - |
| Zinc, New York, spot, lb. | .0467- | .0407- | .0317- |
| Silver, commercial, oz. | .35½- | .33½- | .27½- |
| Cadmium, lb. | .55 - | .55 - | .55 - |
| Bismuth, ton lots, lb. | .85 - | .85 - | .85 - |
| Cobalt, lb. | 2.50 - | 2.50 - | 2.50 - |
| Magnesium, ingots, 99%, lb. | .32 - | .32 - | .30 - |
| Platinum, ref., oz. | 28.50 - | 28.50 - | 37.50 - |
| Palladium, ref., oz. | 17.00 -18.00 | 17.00 - 18.00 | 19.00 - 21.00 |
| Mercury, flask, 75 lb. | 56.00 - | 56.00 - | 62.00 - |
| Tungsten powder, lb. | 1.25 - | 1.25 - | 1.45 - |

## Ores and Semi-finished Products

| | Current Price | Last Month | Last Year |
|---|---|---|---|
| Bauxite, crushed, wks., ton. | $6.50 -$8.25 | $6.50 -$8.25 | $6.50 -$8.25 |
| Chrome ore, c.i.f. ports, ton. | 14.00 -18.50 | 14.00 -18.50 | 17.00 -20.00 |
| Coke, fdry., f.o.b. ovens, ton. | 2.25 - | 2.25 - | 3.25 - 3.75 |
| Fluorspar, gravel, f.o.b. Il., ton. | 17.25 -20.00 | 17.25 -20.00 | 17.25 -20.00 |
| Manganese ore, 50% Mn., c.i.f. Atlantic Ports, unit. | .19 - | .19 - | .25 - .27 |
| Molybdenite, 85% $MoS_2$ per lb. $MoS_2$, N. Y., lb. | .45 - | .45 - | .45 - |
| Monazite, 6% of $ThO_2$, ton. | 60.00 - | 60.00 - | 60.00 - |
| Pyrites, Span. fines, c.i.f., unit. | .13 - | .13 - | .13 - |
| Rutile, 94-96% $TiO_2$, lb. | .10 - .11 | .10 - .11 | .10 - .11 |
| Tungsten, scheelite, 60% $WO_3$ and over, unit. | 10.00 -10.50 | 8.00 -10.00 | 10.00 -10.50 |

# INDUSTRIAL NOTES

MANGANESE STEEL FORGE CO., Philadelphia, has acquired the business and assets of the Audubon Wire Cloth Co., Audubon, N. J.

DOEHLER DIE CASTING CO., on June 1, moved its executive offices from New York, to Toledo, Ohio. A New York sales office will be maintained at 386 Fourth Ave., with L. H. Pillion in charge.

E. F. HOUGHTON & CO., Philadelphia, announces that Major A. E. Carpenter, first vice-president and treasurer has resigned the latter office and was elected general manager. George S. Rogers formerly in charge of the St. Louis and Chicago offices has been appointed general sales manager with headquarters in Philadelphia.

HAVEG CORP., Newark, Del., has appointed John Beard as mid-west representative for the new resinous equipment which the corporation is producing. Mr. Beard is making his headquarters in Cleveland.

PITTSBURGH EQUITABLE METER CO., Pittsburgh, has entered into an arrangement whereby Peacock Brothers, Ltd., Montreal, will manufacture and sell the products of the Pittsburgh company in Canada.

NORTHERN EQUIPMENT CO., Erie, Pa., has appointed C. H. Wilson, 1403 Park Blvd., Troy, N. Y. as sales representative in the Albany district.

GOLWYNNE MAGNESITE & MAGNESIA CORP., New York, has been appointed United States sales agents for a new deposit of ilmenite, zircon, and monozite now being worked in Travancore State, South India.

MAURICE A. KNIGHT, INC., has moved its New York offices from the World Bldg. to 55 West 42d Street. Fred M. Klein continues in charge of the office.

THE W. W. SLY MANUFACTURING CO., Cleveland, has appointed Fred E. Wolf sales engineer in the Pittsburgh district.

THE BRISTOL CO., Waterbury, Conn., announces that the New York office is now located in the Daily News Bldg., 220 East 42d Street.

# NEW CONSTRUCTION

Where Plants Are Being Built in Process Industries

| | This Month | | Cumulative to Date | |
|---|---|---|---|---|
| | Proposed Work and Bids | Contracts Awarded | Proposed Work and Bids | Contracts Awarded |
| New England | ..... | ..... | $165,000 | $108,000 |
| Middle Atlantic | 30,000 | 28,000 | 2,831,000 | 1,759,000 |
| Southern | 471,000 | 1,428,000 | 2,717,000 | 281,000 |
| Middle West | 101,000 | ..... | 802,000 | 272,000 |
| West of Mississippi | 770,000 | 109,000 | 10,771,000 | 674,000 |
| Far West | 380,000 | 28,000 | 1,262,000 | 868,000 |
| Canada | 71,000 | 540,000 | 3,001,000 | 131,000 |
| Total | $1,823,000 | $2,033,000 | $21,549,000 | $4,093,000 |

## PROPOSED WORK BIDS ASKED

**Absorption Plant** — Richfield Oil Co., 551 South Flower St., Los Angeles, Calif., plans to rebuild its absorption plant and casinghead refinery on Signal Hill, Long Beach, Calif., recently destroyed by fire. Loss estimated between $350,000 and $1,000,000.

**Absorption Plant**—Turner Valley Oil Field Producers, Alberta, Mont., plan the construction of a naptha absorption plant and carbon black unit. $500,000.

**Chemical Plant**—Great Western Electro Chemical Co., Pittsburgh, Calif., plans to construct an addition to its plant. Leland Rosener, 233 Sansome St., San Francisco, is architect. $30,000.

**Chemical Plant**—Virginia Carolina Chemical Co., West Tremont St., Charlotte, N. C., contemplates rebuilding its storage plant recently destroyed by fire. $70,000.

**Cotton Oil Plant** — Delta Cotton Oil Co., Jackson, Miss., plans to construct a 1 story addition to its plant. Estimated cost with equipment $28,000.

**Glass Factory** — Corporation, c/o William Koach, Star City, W. Va., plans to alter a factory at Kane, Pa., to be used for a glass factory. Estimated cost with equipment $28,000.

**Glass Factory** — Owens Illinois Glass Co., Kanawha City, W. Va., plans to build an addition to its factory. $150,000.

**Gas Plant**—City, Bradford, Pa., contemplates the construction of a gas plant, including lines. $30,000.

**Laboratory, etc.** — Los Angeles General Hospital, Los Angeles, Calif., W. Davidson, Chief Mechanical Engr., Hall of Records, has appropriated $36,000 for clinics and operating room equipment, $15,000 for pathological laboratory and $45,000 for X-ray department.

**Laboratory Equipment** — National Research Council of Canada, Ottawa, Ont., plans to purchase additional laboratory equipment. $25,000.

**Lime and Chlorine**—State Board of Control, Ottawa, Ont., Can., is receiving bids for supply of lime and chlorine for filtration plant on Lemiliese Island.

**Oil Refinery**—C. Grieve, 1208 Clifton St., Moose Jaw, Sask., plans the construction of a small oil refinery and is interested in prices of equipment. $15,000.

**Oil Refinery** — Corn Products Refining Co., Brookes Bldg., Kansas City, Mo., and 17 Battery Pl., New York, N. Y., plans the construction of a refinery at North Kansas City. $50,000.

**Oil Refinery**—Phillips Petroleum Co., Bartlesville, Okla., is having plans prepared for a 1 story refinery at Okmulgee. $150,000.

**Oil Refinery**—Stephens Refining Co., W. B. Sassett, Gen. Mgr., Stephens, Ark., is having preliminary plans prepared for a refinery. $70,000.

**Paint Factory**—Hebert Paint & Varnish Co., Ltd., Calgary, Alta., plans to build an addition to its factory.

**Vegetable Parchment Plant**—Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich., plans the construction of an addition to its plant. Estimated cost $45,000. Bellingham & Cobb, Kalamazoo, are architects.

**Paper Mill** — Menasha Mill Supply Co., Menasha, Wis., plans to rebuild its paper mill recently destroyed by fire.

**Warehouse** — McLeod Pulp & Paper Co., Rapid Falls, N. S., plans the erection of an arking mill and pulp storage warehouse.

**Crushing Mill**—Georgia Silica & Mineral Co., c/o John D. Parks, Etowah, Tenn., plans to construct a 3 story crushing mill. $45,000.

**Powder Mill**—Bronze Powder Corp., Painesville, O., contemplates repairs and alterations to its mill. $28,000.

**Smelter and Refinery**—Japan Nickel Co., Ltd., Kobe, Japan, plans the construction of a smelter and refinery to have a daily capacity of 6,000 lb. refined nickel.

**Tin Mill**—American Consolidated Tin Mines Corp., c/o Chamber of Commerce, Lincolnton, N. C., has acquired a site consisting of 652 acres and is having plans prepared by Ulysses D. James, Newark, N. J., for a tin mill. Initial mill unit to have a capacity of 100 tons per day, and to be designed to be readily capable of expansion into as many more similar units. Dr. Jno. H. Banks is consulting engineer.

## CONTRACTS AWARDED

**Cement Plant**—Metropolitan Cement Co., W. D. Cloos, in charge, 261 5th Ave., New York, N. Y., plans to remodel potash plant at Raritan, N. J., to be used for cement manufacturing plant. New additions will be built. Work will be done by separate contracts. M. Heintal, c/o Owner, is architect and engineer. $500,000.

**Chemical Plant**—Calco Chemical Co., Inc., W. S. Weeks, in charge, Bound Brook Rd., Bound Brook, N. J., will build a manufacturing plant by day labor. $100,000.

**Glass Factory** — Hart Glass Co., Dunkirk, Ind., awarded contract for 1 story, 64x282 ft. factory to A. J. Glasser, Lincoln St. and Big Four R.R., Muncie. Estimated cost $28,925.

**Laboratory**—National Motion Pictures, c/o H. W. Kier, South Texas Bank Bldg., San Antonio, Tex., will build a motion picture studio to include a 1 story, 42x60 ft. laboratory. Work will be done by day labor.

**Match Factory** — Barberton Match Works, Barberton, O., awarded contract for factory and power plant to W. Barnard, Barberton. Estimated cost with equipment $30,000.

**Match Factory**—Palmer Match Co., Kenmore, Akron, Ohio, will build a 2 story, 75x138 ft. match factory in Kenmore. Work will be done by separate contracts. $20,000.

**Paint Factory**—Adelphia Paint & Color Works, Old South Rd. and 86th St., Ozone Park, L. I., awarded contract for altering and repairing its factory here to Shatto Construction Co., 86th St. and Old South Rd. $28,000.

**Rayon Factory**—Celanese Corp. of America, Amcelle, Cumberland, Md., awarded contract for factory here to Hughes-Foulkrod Co., 1505 Race St., Philadelphia, Pa. Estimated cost $300,000.

**Oil Refinery**—Shell Oil Co., Shell Bldg., San Francisco, Calif., awarded contract for rebuilding bleacher unit of refinery at Martinez, Calif., recently destroyed by fire, to Judson-Pacific Co., 18th and Campbell Sts., Oakland. $40,000.

**Refinery**—American Smelting & Refining Co., 120 Bway., New York, N. Y., and Salt Lake City, Utah, plans tunnel and shaft for ore body exploration at Boston Consolidated Sulphide properties. Owner will do work by day labor and purchase all materials. $500,000.

**Oil Topping Plant**—Wolverine Empire Refining Co., Franklin, Pa., awarded contract for oil topping plant to have a capacity of 2,000 bbl., also a rerun unit with the same capacity, to Alco Products, Inc., 220 East 42nd St., New York, N. Y. Estimated cost $200,000.

**Topping Still and Pulverizing Plant**—Gulf Refining Co., Gulf Bldg., Pittsburgh, Pa., is building a topping still and pulverizing plant on Neville Island near Pittsburgh. Contract for concrete foundation piles has been let to Raymond Concrete Pile Co., Pittsburgh, rest of work is being done by company's own forces, wherever possible.

**Refinery** — Compania Mexicana "El Aquila (Mexican Eagle Oil Co., Tampico and Mexico City), Mexico, awarded contract for refinery at Tampico to Alco Products Co., 220 East 42nd St., New York, N. Y. Estimated cost $1,000,000.

**Rubber Factory** — Goodyear Rubber Co., Hotchkiss St., Middletown, Conn., awarded contract for a 1 story, 46x50 ft. addition to its plant to be used as a vulcanizing shop to C. O. Stone & Son, Inc., Fairview St., Portland, Conn.

**Smelter**—Master Metals & Floor Surfacing Materials, S. Flesheim, Pres., 2850 West 3rd St., Cleveland, O., awarded contract for 70x100 ft. smelter, 20x96 ft. bins and 20x40 ft. office to Cleveland Service Co., East 40th St. and St. Clair Ave., Cleveland. Estimated cost $30,000.

**Filter Plant**—West Virginia Pulp & Paper Co., started construction by their own forces on new filter plant in connection with their local plant at Covington, Va. Estimated cost $100,000.

**Warehouse**—Scholler Bros., Inc., Ambler and Westmoreland Sts., Philadelphia, Pa., awarded contract for warehouse at their soap factory to William F. Lotz, Oxford Bank Bldg., Philadelphia. Estimated cost $100,000.